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NATIONAL DAM SAFETY PROGRAM. WOLF DEN DAM (NJ00215), PASSAIC RI--ETC(U)
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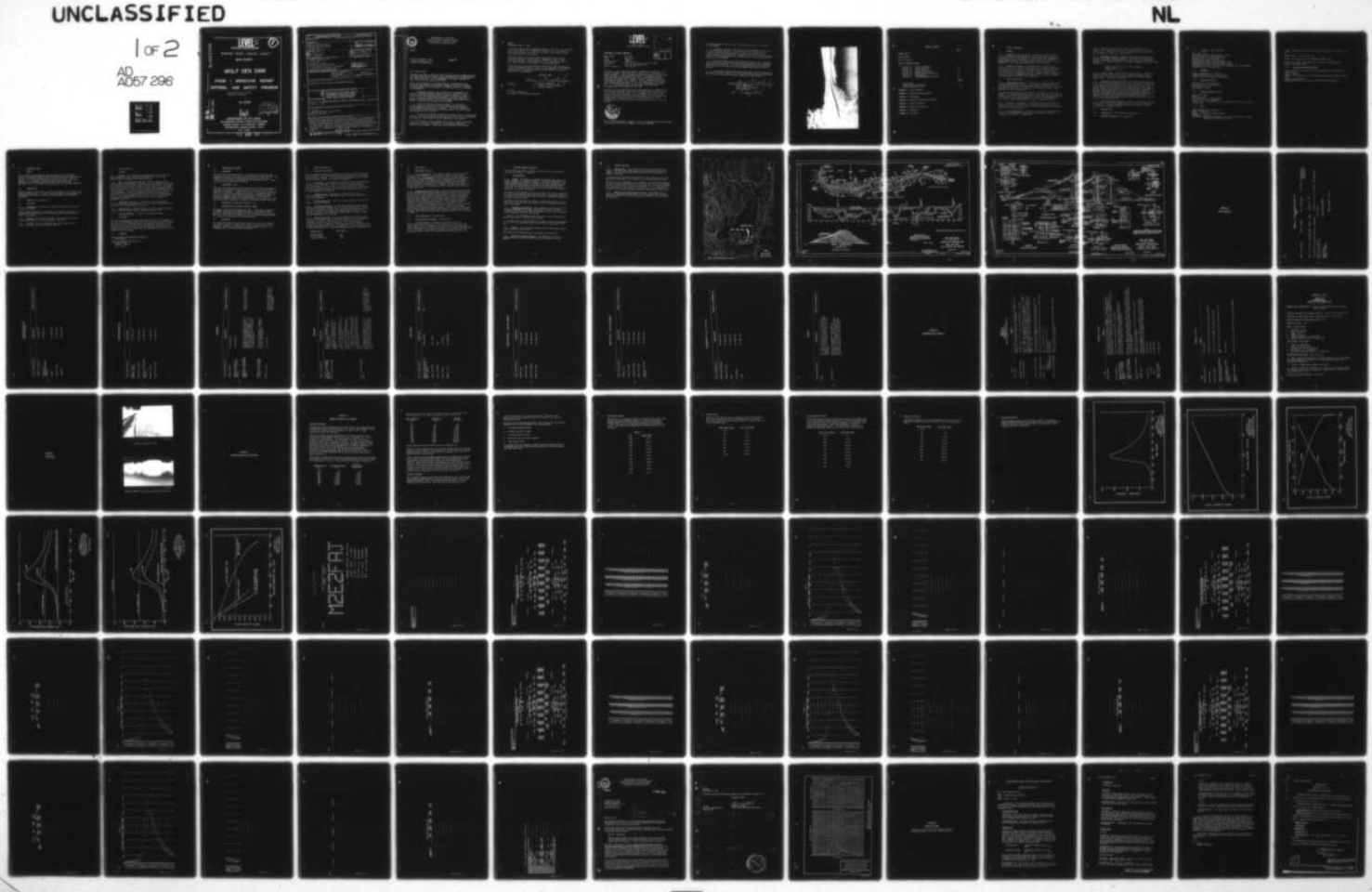

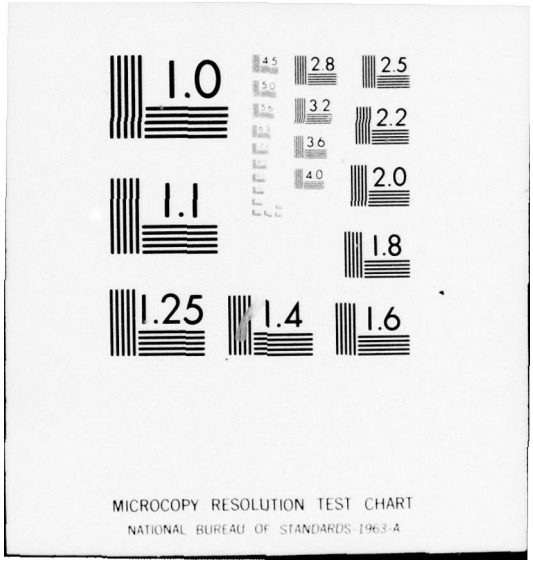
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LEVEL II

PASSAIC RIVER BASIN

WANAQUE RIVER, PASSAIC COUNTY

NEW JERSEY

WOLF DEN DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

NJ 00215

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

JULY 1978

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NJ00215
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): Phase I Inspection Report
National Dam Safety Program
Wolf Den Dam (NJ00215)
Passaic County, N.J.

5. TYPE OF REPORT & PERIOD COVERED: (9) FINAL Rept.
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7. AUTHOR(s): (10) James A. Hagen, P.E.

8. CONTRACT OR GRANT NUMBER(s): (15) DACW61-78-C-0114

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Gilbert Associates, Inc.
P.O. Box 1489
Reading, Pa. 19603

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Engineer District, Philadelphia
Custom House, 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106

12. REPORT DATE: (11) July 1978
13. NUMBER OF PAGES: 98

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (12) 103 p.

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Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(6) National Dam Safety Program. Wolf Den Dam (NJ00215), Passaic River Basin, Wanaque River, Passaic County, New Jersey. Phase I Inspection Report.

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams--N.J.
National Dam Safety Program Phase I
Wolf Den Dam, N.J.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy of adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

3 AUG 1978

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Wolf Den Dam in Passaic County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first two pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Wolf Den Dam is judged to be in fair condition. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Engineering studies of the phreatic line and embankment soils should be performed within one year of the date of approval of this report to determine corrective actions required to reduce the potential for soil piping during high water elevations. Necessary corrective measures, including removal of trees and embankment slope stabilization, should be initiated upon completion of the studies.

b. Within six months of the date of approval of this report a periodic inspection program for the entire dam should be implemented and a maintenance manual should be developed. The periodic inspection program should include monitoring of the flow rates at the minor seepage areas beyond the toe of the dam.

c. A qualified engineering geologist should begin review of seismographic records of the blasting adjacent to the east of the dam as soon as practicable and finish the review within 30 days of completion of the blasting.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter,

NAPEN-D
Honorable Brendan T. Byrne

a copy will also be sent to Congressman Robert A. Roe of the Eighth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,

Harry V Dutchyshyn

1 Incl
As stated

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

Cy furn:
Mr. Dirk C. Hofman, P.E.
Department of Environmental Protection

LEVEL II

Phase I Report
National Dam Safety Program

ASSESSMENT OF GENERAL CONDITION

Name of Dam:	Wolf Den
State:	New Jersey
County:	Passaic
USGS Quad Sheet:	Wanaque, N. J.
Coordinates:	N 41° 02' 24" LAT., W 74° 18' 18" LONG.
Stream:	None (Off the Wanaque River)
Dates of Inspection:	9-11 May 1978

This dam is in good condition as defined in Appendix H, Conditions. It is actually a series of three dams which is named as one of nine dams on Wanaque Reservoir. It has an excessive tree growth on the downstream slopes which is presently being removed by the Owner. To expedite clearing operations this removal must continue, with the slope being immediately stabilized with grasses and/or legumes. There is rock blasting activity occurring near the north end of the dam. The blast monitoring information should be furnished by the Owner to the Corps of Engineers and reviewed soon. It is recommended that a periodic inspection program and a maintenance manual be developed for this dam.

The dam will not be overtopped by the probable maximum flood (PMF) but the reservoir level under PMF conditions will be higher than both the impervious soil zone and the concrete core. It is recommended that studies of the phreatic line and the embankment soils be performed in the near future to determine the potential for soil piping during high water elevations. The drawdown time for Wanaque Reservoir is considered excessive. It is recommended that in the near future a larger capacity drawdown facility be provided.

JAMES A. HAGER
REGISTERED
No. 4767
DELAWARE
PROFESSIONAL ENGINEER

Based on visual inspection, available records, calculations and past operational performance, Wolf Den Dam is judged to be in fair condition.

To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Engineering studies of the phreatic line and embankment soils should be performed within one year of the date of approval of this report to determine corrective actions required to reduce the potential for soil piping during high water elevations. Necessary corrective measures, including removal of trees and embankment slope stabilization, should be initiated upon completion of the studies.

b. Within six months of the date of approval of this report a periodic inspection program for the entire dam should be implemented and a maintenance manual should be developed. The periodic inspection program should include monitoring of the flow rates at the minor seepage areas beyond the toe of the dam.

c. A qualified engineering geologist should begin review of seismographic records of the blasting adjacent to the east of the dam as soon as practicable and finish the review within 30 days of completion of the blasting.

APPROVED: Harry V Dutchyshyn

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

DATE: 3 Aug 1978

May 1978

WOLF DEN DAM

TABLE OF CONTENTS

1.0 PROJECT INFORMATION

1.1 GENERAL

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the U.S. Corps of Engineers to initiate a national program of safety inspections of non-Federal dams throughout the United States. Gilbert Associates, Inc. has entered into a Contract, Number DACW61-78-C-0014, with the Philadelphia Office of the U.S. Corps of Engineers to inspect this dam, Gilbert Work Order 06-7249-000.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams (Reference 1) and contract requirements between Gilbert Associates, Inc. and the Corps of Engineers. The objectives are to expeditiously identify whether this dam apparently poses an immediate threat to human life or property, and to recommend future studies and/or any obvious remedial actions that may be indicated by the inspection.

1.2 PROJECT DESCRIPTION

1.2.1 Dam and Appurtenances: Wolf Den Dam is a series of three earth embankments separated by rock knoll. The dam has a maximum height of 42-feet above natural ground and an aggregate length of 2,200 feet. The record drawings indicate it has a concrete core with an impervious zone on the upstream side (see Figures 2 and 3).

This dam has a blowoff pipe near the center of the westerly section (see Figure 3). The blowoff pipe consists of a 12-inch cast iron pipe to the dam centerline and a 18-inch reinforced concrete pipe to the downstream toe. As with the other dams on Wanaque Reservoir, it relies on the Overflow Weir (N.J. 00214) to pass excess storm water runoff. (See Location Map)

1.2.2 Location: Wolf Den Dam is located about one-third mile west of New Jersey Route 511 at Wanaque, N.J., and about one-third mile south of Raymond Dam. The location of the dam is shown on the geologic map, Appendix F and the Location Map, Figure 1.

1.2.3 Size Classification: The dam is classified as a large structure because of its impoundment (77,950 acre-feet at elevation 310 feet), according to Section 2.1.1 of Reference 1.

1.2.4 Hazard Classification: The dam is located upstream of a moderately heavily populated valley and floodplain area, which includes several towns. The dam is classified as a high hazard potential based on the requirements of Section 2.1.2 of Reference 1.

1.2.5 Ownership: The dam is owned and maintained by the North Jersey District Water Supply Commission (NJDWSC), a New Jersey state commission. They have engineering and maintenance facilities located at Raymond Dam in Wanaque, N. J. The Chief Engineer of the NJDWSC in Wanaque is Mr. Dean C. Noll. The address is:

North Jersey District Water Supply Commission
Ringwood Avenue
Wanaque, N. J. 07465

1.2.6 Purpose of Dam: Wolf Den Dam serves as a series of saddle dams which close off low areas in the rim of the Wanaque Reservoir, which supplies water to residents of Paterson, Montclair, Glen Ridge, Newark, Kearny, Passaic, and Clifton, New Jersey.

1.2.7 Design and Construction History: This dam was constructed from July 12, 1925 to July 25, 1927 by the Clifford F. MacEvoy Co. of Newark, N. J., as part of the total Wanaque Project. The project began in 1920. The dam was completed and the reservoir was filled by March 4, 1929. The original design records could not be located by the staff of the NJDWSC at Wanaque. However, publications indicate the design was performed by employees of the NJDWSC with the assistance of individual consultants. The New Jersey Department of Environmental Protection (DEP) has some monthly progress inspection reports and several photographs taken during construction. There are no indications of revisions or repairs to the dam since its original construction.

1.2.8 Normal Operational Procedures: There is no operational procedure for this dam. It relies on adequate freeboard to contain storm surges in the reservoir, with overflow handled by the Overflow Weir (NJ 00214) 0.2 miles east of the Wolf Den Dam.

1.3 PERTINENT DATA

1.3.1 Drainage Area: 90.4 square miles (Reference 4)

1.3.2 Discharge at Dam Site: Not Applicable.

1.3.3 Elevation: (Feet above MSL)

Top of Dam - 310.0
Spillway Design Flood (SDF) Surcharge - 308.8
Full flood control pool - Not applicable
Recreation pool - Not applicable
Spillway crest (gated) - Not applicable
Upstream portal invert diversion tunnel - 268.5
Downstream portal invert diversion tunnel - 264.7
Streambed at centerline of dam - 268.0 (topographic low, not streambed)
Maximum tailwater - Not applicable

1.3.4 Reservoir:

Length of Maximum Pool - 6.6 miles
Length of Recreation Pool - Not applicable
Length of Flood Control Pool - Not applicable

1.3.5 Storage (Acre-feet):

Recreation Pool - Not applicable
Flood Control Pool - Not applicable
SDF Surcharge - 76,400
Top of Dam - 77,950

1.3.6 Reservoir Surface (acres):

Top of Dam - 2,620
SDF pool - 2,590
Flood control pool - Not applicable
Recreation pool - Not applicable
Spillway crest - No spillway; 2,364 at normal reservoir overflow elevation of 302.4 feet.

1.3.7 Dam:

Type - Earthfill with concrete core
Length - 2,200 feet
Height - 42 feet (above ground surface)
Top Width - 15 feet
Side Slopes - Upstream 2 horizontal:1 vertical to 3 horizontal:1 vertical
Downstream 2 horizontal:1 vertical

Zoning - impervious soil zone next to the upstream side of the concrete core wall

Impervious Core - Concrete core wall

Cutoff - The concrete core wall reputedly extends to rock.

Grout Curtain - None. The upper part of the core wall foundation was grouted to a shallow depth

1.3.8 Diversion and Regulating Tunnel:

Type - Pipe Blowoff (12 inch cast iron pipe becoming 18-inch reinforced concrete pipe.)
Length - 230 feet
Closure - 12 inch globe valve with backup 12-inch gate valve with non-rising stem.
Access - Concrete manhole
Regulating Facilities - Valve stem to manhole cover (see Figure 3)

2.0 ENGINEERING DATA

2.1 DESIGN

A plan, profile, and maximum section through the dam and some borrow material investigation plans are shown on original record tracings which are on file at the NJDWSC engineering office (Contact Mr. Dean C. Noll) at Wanaque, N.J. No original design data were available other than results mentioned in the North East Water Works Association publication (Reference 2) and a 1925 report by the Commissioner of the NJDWSC (Reference 3).

2.2 CONSTRUCTION

Contract drawings, specifications, and record drawings, are available at the NJDWSC engineering office. Periodic inspection reports, news clippings, and photographs are available at the New Jersey Department of Environmental Protection.

2.3 OPERATION - Not applicable

2.4 EVALUATION

2.4.1 Availability: Information on foundation exploration and design analyses is lacking.

Data on embankment material and placement are incomplete. The record drawings which show the extent of rock excavation and foundation grouting results are available.

2.4.2 Adequacy: The available drawings and other data received and reviewed were adequate for use in this Phase I dam report.

2.4.3 Validity: The record drawings appear to be consistant with observed structures based on the visual inspection.

3.0 VISUAL INSPECTION

3.1 FINDINGS

3.1.1 General: Wolf Den Dam has apparently served well in the past. Minor seepage was noted in several areas beyond the toe of the dam. Numerous trees are growing on the downstream slope.

3.1.2 Dam: The downstream slopes were relatively uniform with no visible evidence of instability. The majority of the downstream was covered with a moderately dense growth of small to medium sized trees. In several areas, trees had been recently cleared with the stumps left in the ground. The upstream slope was lined with riprap and was in good agreement with the record drawings. At least five areas of seepage were located beyond the toe of the embankment. Most of the seepages occurred about five to 15 feet beyond the toe with an average estimated flow of two to five gallons per minute . All of the seepage water was clear at the time of the inspection. For details of seepage location and occurrence, refer to Appendix A - Embankments, page A-5.

3.1.3 Appurtenant Structures: At the blowoff pipe (construction drainage diversion) an estimated flow of five to ten gallons per minute of clear water was passing from the pipe outlet.

3.1.4 Reservoir Area: Gneissic bedrock, continuously exposed along the reservoir rim near the dam, exhibits apparently stable slopes.

3.1.5 Downstream Channel: - There is no downstream channel.

3.2 EVALUATION

The relatively uniform side slopes and the lack of any critical signs of distress of the embankment indicate that the dam itself is in good condition (see Appendix H). All seepage discovered beyond the embankment toe areas appears to be within tolerable limits. The numerous trees growing on the downstream slope should be removed and the banks kept clear of trees to prevent deep penetration of their roots and the eventual formation of piping channels as the roots decay.

3.3 ATTENDEES

New Jersey Dept. of Environmental Protection
Larry Woscyna

Gilbert Commonwealth Associates, Inc.
James A. Hagen
Rudolph J. Wanahik
Fine T. Hsu

4.0 OPERATIONAL PROCEDURES

4.1 PROCEDURES

The water level in Wanaque Reservoir is maintained by the Overflow Weir structure, 0.2 mile to the east, to a pool elevation of 302.4 feet MSL. The highest water elevation recorded since October 1950 was 303.93 feet (Reference 6) with excess flow passing over the uncontrolled weir. There is no operational procedure for Wolf Den Dam.

4.2 MAINTENANCE OF DAM

There has evidently been periodic maintenance and surveillance performed on this dam. The roadway on top of the dam is cleared of trees and easily traversed by automobile. A NJDWSC security patrol travels daily around the reservoir in 4-wheel drive vehicles and on foot. They regularly pass over this dam on their patrol and have been instructed by NJDWSC personnel to observe for leakage or areas requiring maintenance. Tree removal is reported by NJDWSC personnel to be planned within the next two years. Trees have been removed on the easterly portion of the center segment of the dam.

4.3 MAINTENANCE OF OPERATING FACILITIES - N.A.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

No automatic warning systems existat this dam. A daily patrol is made by the NJDWSC security guards equipped with radios. According to NJDWSC personnel, the guards are instructed to radio the guard house, or failing that, to directly radio the Wanaque police of any obvious, impending hazard to residents from the dams on the Wanaque Reservoir.

4.5 EVALUATION

The seepage areas should be periodically observed and flow rates measured. Tree and brush removal is needed; tree removal is planned and partially completed. Otherwise, the maintenance appears adequate; however, it is recommended that a maintenance manual be prepared.

5.0 HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

Other than the dam, there are no hydraulic structures or control facilities at this location. Excess storm water runoff is discharged at the Overflow Weir, 0.2 mile to the east. Details on the methodology used in this report and the hydrologic results are presented in Appendix D.

5.1.1 Design Data: The maximum pool elevation for the design discharge of 18,000 cfs is 304.3 feet. This is based on the original spillway elevation of 300.3 feet plus a head of 4.0 feet, for the Overflow Weir. With the flashboards in place, the overflow structure becomes a sharp edged weir with an elevation of 302.4 feet, and a pool elevation of 306.6 feet with the design flow of 18,000 cfs.

5.1.2 Experience Data: The maximum recorded reservoir level is 303.9 feet, (March 31, 1951) (References 6 and 7) 6.1 feet lower than the crest of Wolf Den Dam.

5.1.3 Visual Observations: There is no visual evidence to indicate the dam has ever been overtopped.

5.1.4 Overtopping Potential: The PMF, when developed as described in Appendix D and with the flashboards in place on the Overflow Weir, results in a reservoir elevation of 308.8 feet. One-half of the PMF results in a reservoir elevation of 306.0 feet, with the flashboards in place. As discussed in Section 7.0, the PMF and 1/2 PMF reservoir levels are higher than the impermeable core of the dam.

5.1.5 Reservoir Drawdown: The existing emergency drawdown facilities installed in the several dams of the Wanaque Reservoir are not adequate to lower the water level of the reservoir in a short period of time. A preliminary evaluation of the performance of the existing drawdown facilities is given in Appendix D. The time required to draw down the Wolf Den Dam from Elevation 302.4 (top of flashboards) to the bottom surface level of Wolf Den Dam (268 feet), using the existing facilities at Raymond Dam is:

System in Use	Time in Days
Aerator System	144
36" Dia Blowoff	445
Aerator and Blowoff	108

6.0 DAM STABILITY

6.1 STRUCTURAL STABILITY

6.1.1 Visual Observations: The earthfill dam has relatively uniform side slopes. All seepages occurring beyond the toes are well within tolerable limits. It is not anticipated that these seepages would result in significant soil Surficial soils on the downstream slope are primarily silty sand and gravel; the exposed rocks are composed of biotite gneiss to granitic gneiss with folation bearing about 60° (striking N 20°-40°E, dipping 30°-45°SE) to the dam axis. In summary, the dam itself appears to be structurally sound with satisfactory static stability under its historic loading conditions.

6.1.2 Design and Construction Data: The record drawings indicate that the upstream impermeable material extends upward to only elevation 300 feet which is 2.2 feet lower than the normal overflow elevation of the reservoir. This condition is undesirable to the extent that it offers no secondary barrier to the passage of water through the core and will not provide any temporary delay of hydraulic forces on the concrete core due to brief increases in the elevation of the reservoir. The foundation rocks were reported to be broken and seamy; therefore, a large amount of rock excavation, together with foundation grouting was done, in order to provide a stable foundation for the concrete corewall. There were no other descriptions of impervious material except as clay (C), loam (L) clay mixed with varying proportions of gravel and sand (CGS) as shown on the contract drawings. Data on foundation and slope stability analyses are not available for review.

6.1.3 Operating Records: Not applicable.

6.1.4 Post Construction Changes: Not applicable.

6.1.5 Seismic Stability: The dam is located within Zone 1 on Algermissen's Seismic Risk Map of the United States (1969 edition), the static stability of the dam appears to be satisfactory and conventional safety margins appear to exist, and, therefore, in accordance with paragraph 3.6.4 of Reference 2, the dam may be assumed to present no hazard from earthquakes (under its historic loading conditions referred to in 6.1.1.).

7.0 ASSESSMENT/REMEDIAL MEASURES

The assessment and remedial measures contained herein are based on the provisions of Appendix J, Conditions.

7.1 DAM ASSESSMENT

7.1.1 Safety: No evidence was obtained to show that this dam in its present condition is structurally unsound. The inflow hydrograph for the probable maximum flood (PMF), as supplied by the Corps of Engineers, was routed through Wanaque Reservoir by means of the HEC-1 computer program. These results indicate that the dam will not be overtopped under PMF conditions. The time required to draw the reservoir down under emergency conditions is in excess of 108 days.

The water level has exceeded the top of the impervious soil zone upstream of the concrete core numerous times in previous years. The impact of this on the safety of the dam requires further studies and analyses which should be performed in the near future.

The numerous trees growing on the slopes of the dam could result in root penetration of the core wall and eventually result in leakage, which could lead to soil piping.

7.1.2 Adequacy of Information: The assessments are based primarily on the record drawings and the visual inspection of the dam. Further information which should be supplied by the Owner to the Corps of Engineer's to more completely review the dam includes:

a. Records of the seismograph during blasting for a new treatment plant being built adjacent to the east end of the dam.

b. Information on the piping potential and phreatic line of the embankment material above the impervious blanket and the material downstream of the core.

7.1.3 Urgency: The tree cutting program started by the Owner should be completed within the near future.

Blast monitoring information should be obtained and reviewed soon.

7.1.4 Necessity for Further Studies: The sampling and testing of embankment material referred to above should be performed in the near future.

7.2 REMEDIAL MEASURES

7.2.1 Alternatives: Trees and brush should be cleared from the side slopes. The slopes should then immediately be revegetated with grass or legumes. Trees and thick bushes should be prevented from growing on the slopes in the future.

In the near future, the Owner should provide a water release facility that would allow the reservoir to be lowered in an acceptable period of time.

Detailed studies of embankment soils and phreatic conditions should be made, in order to determine the possibility of piping or erosion in the embankment when the reservoir level is above the top of the core. If remedial measures are found necessary, they should be performed soon. If test borings are performed in the program, piezometers should be installed in selected holes.

7.2.2 Operational and Maintenance Procedures: Tree removal must be continued to keep trees off the slopes. It is recommended that a periodic inspection program and a maintenance manual be prepared in the near future for this dam.

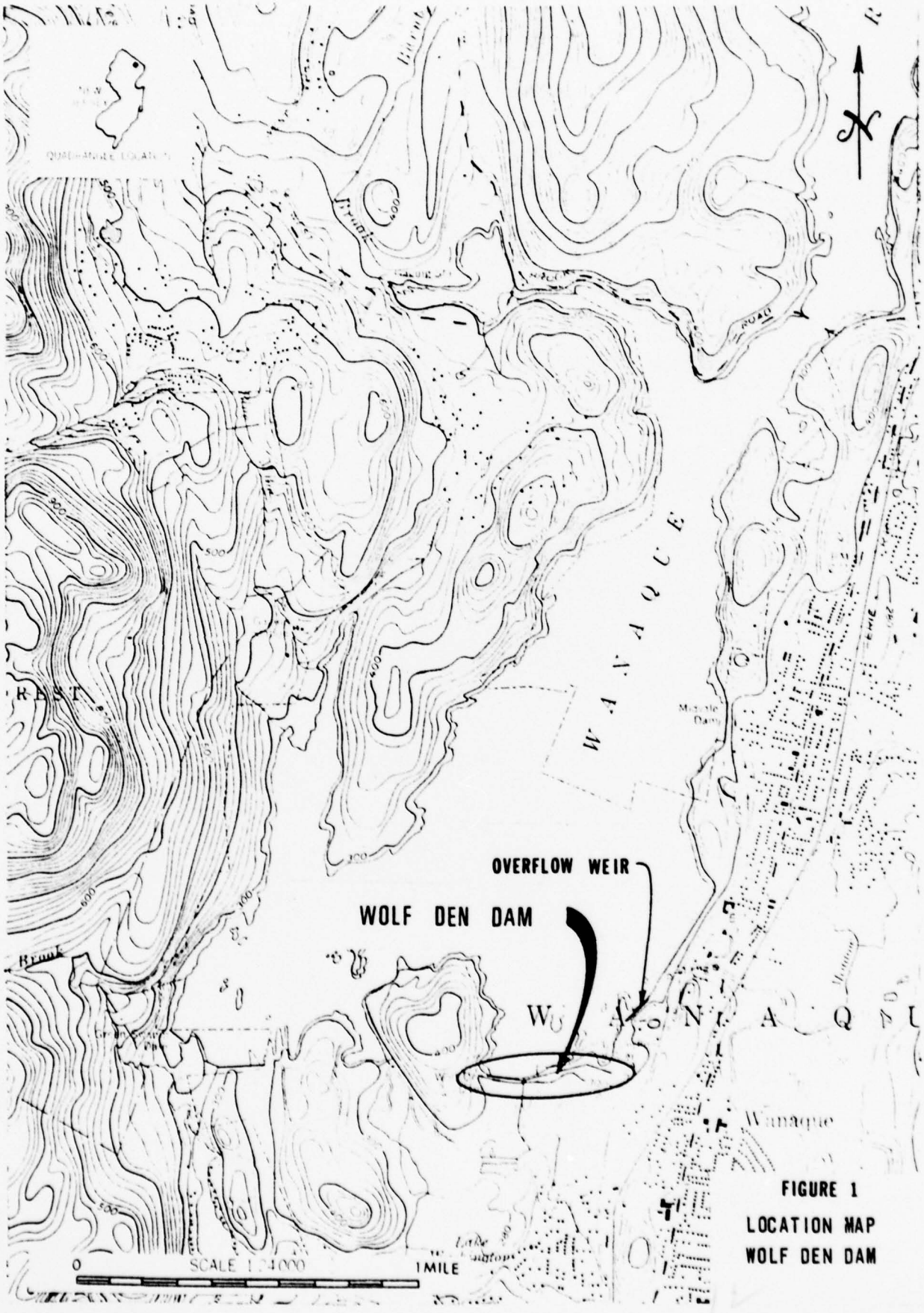
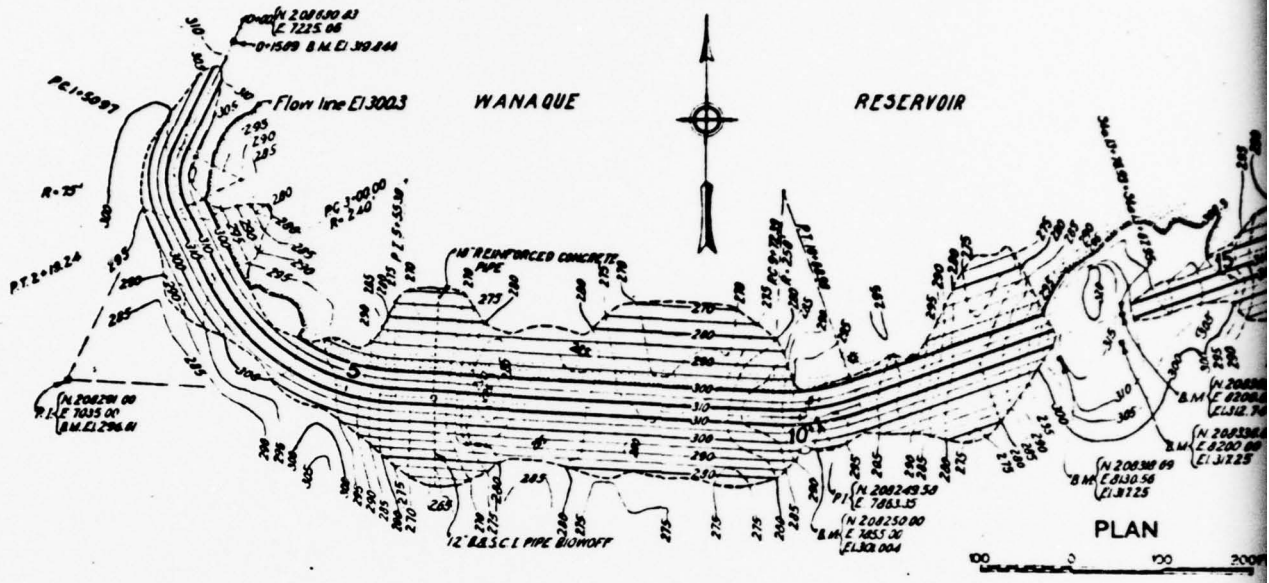


FIGURE 1
LOCATION MAP
WOLF DEN DAM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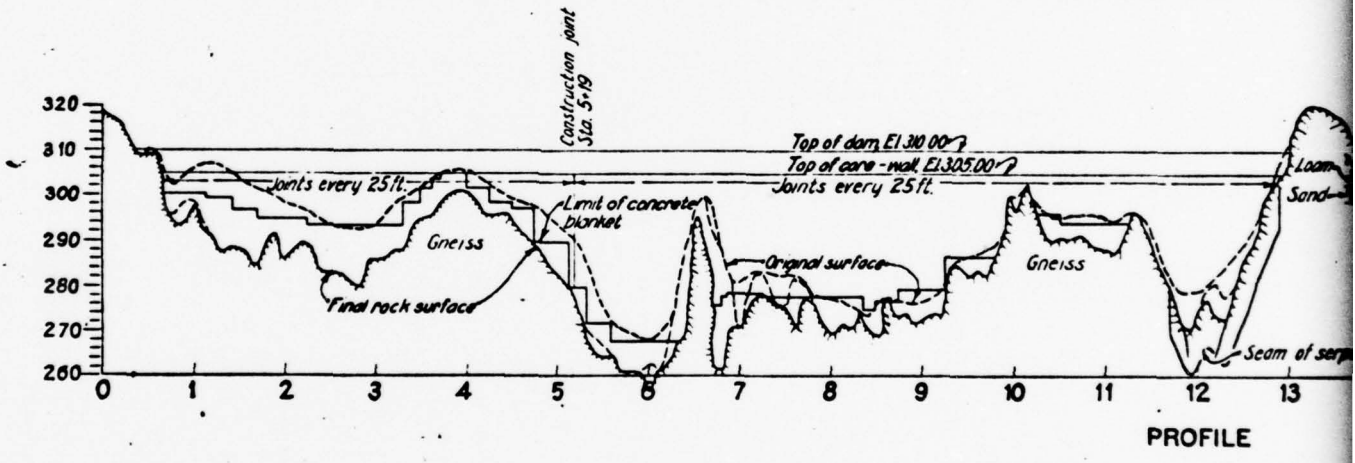
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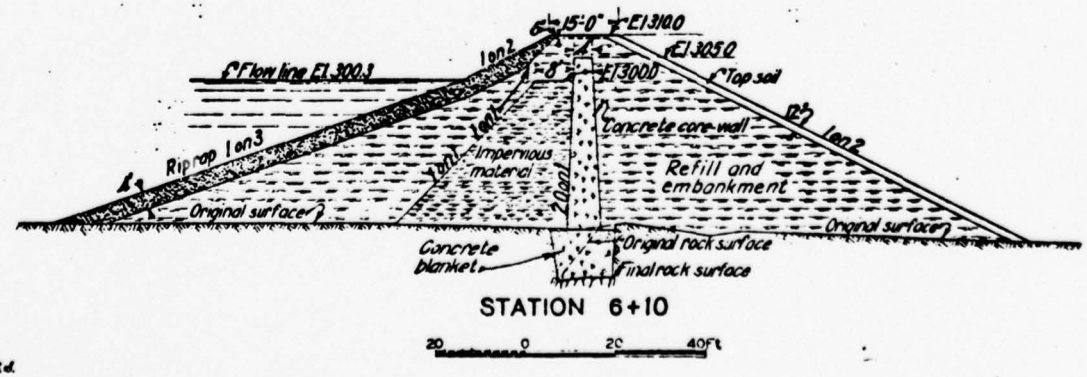
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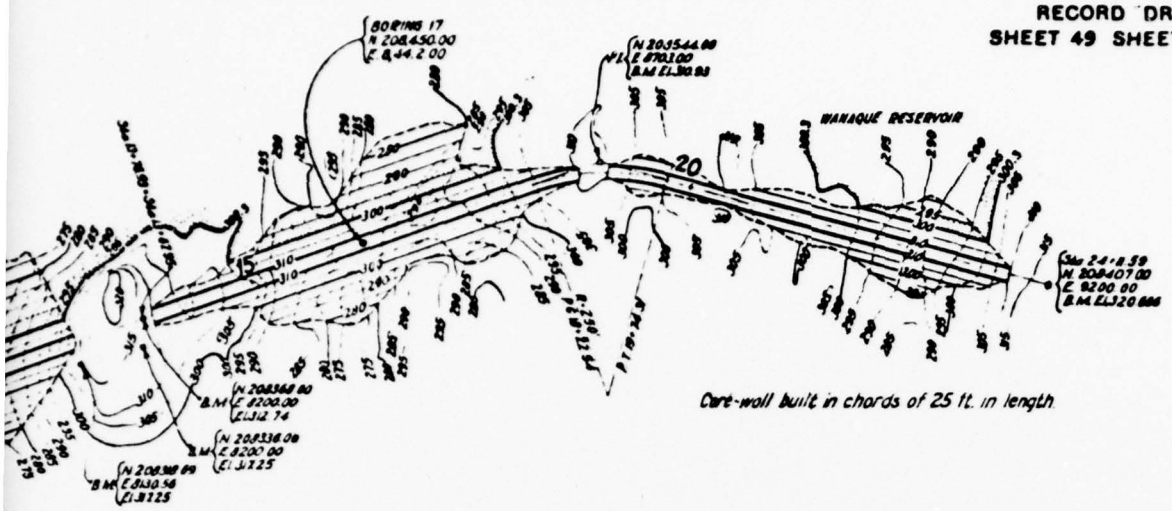
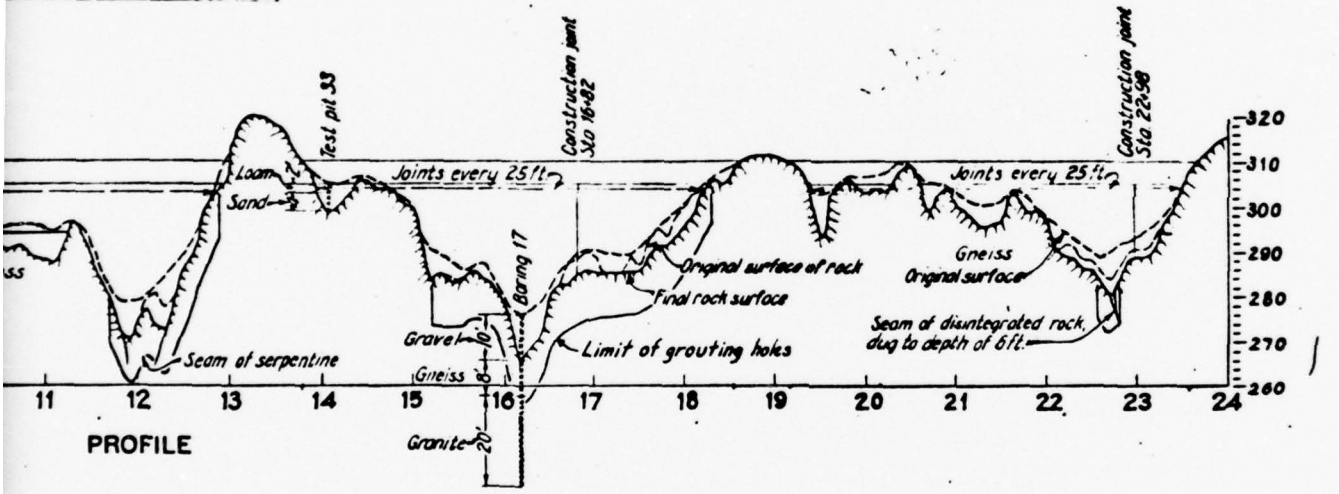
RECORD DRAWING
SHEET 49 SHEETS IN SET 61





NOTE:-Bench marks are ⅝" brass rods caulked into ledge rock

CONSTRUCTION RECORD

Constructed July 12, 1925 to July 25, 1927, under Contract 7, Clifford F. MacEvoy Co., Newark, N.J., Contractor, as shown on this record drawing

Engineer in charge.

NORTH JERSEY DISTRICT
WATER SUPPLY COMMISSION

WANAQUE RESERVOIR

WOLF DEN DAM

PLAN, PROFILE AND SECTION

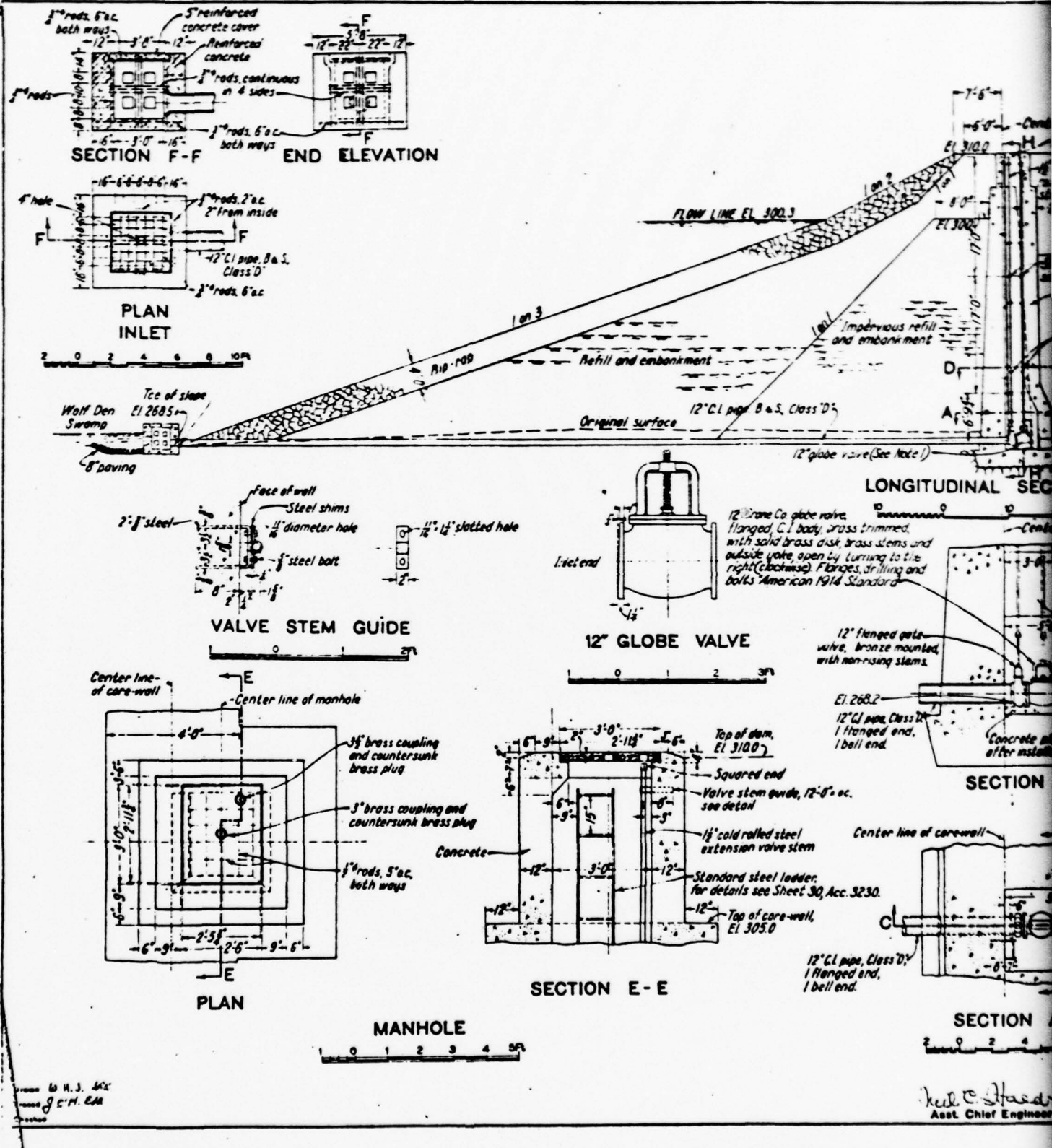
APRIL 30, 1931

Neil C. Haedrich
Asst. Chief Engineer

FIGURE 2

CASE C DR. 12 File- 3.42Wwd Acc. 3249

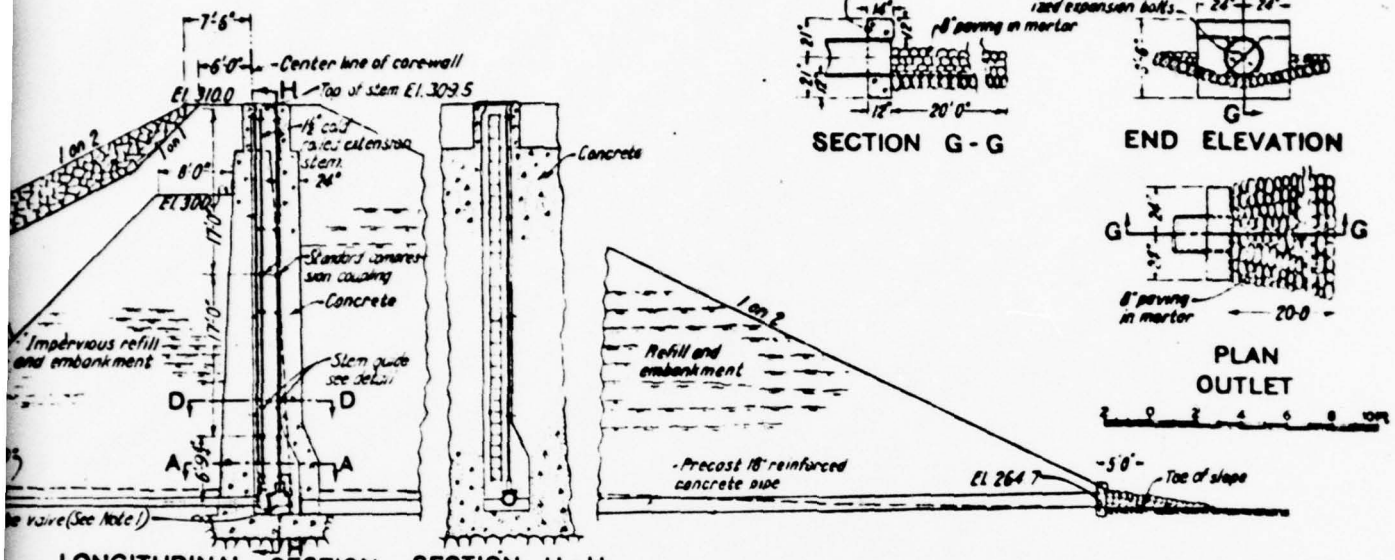
2

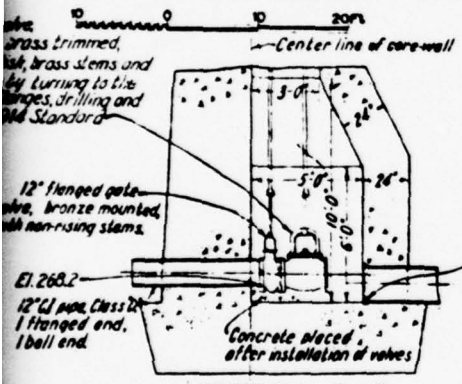


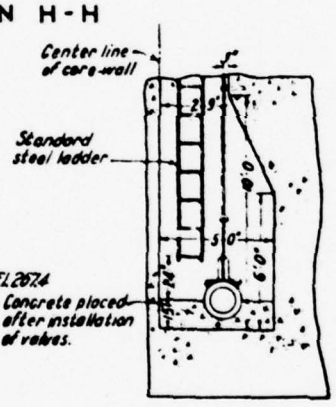
Asst. Chief Engineer

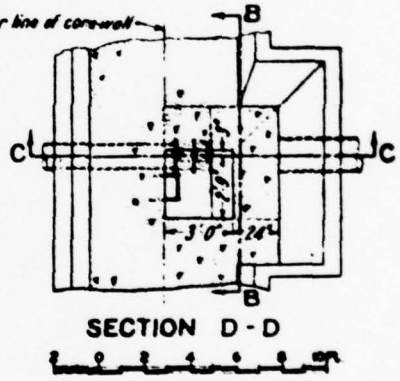
RECORD DRAWING

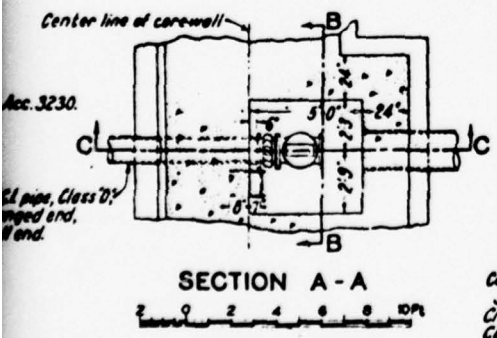
SHEET 51 SHEETS IN SET 61











NOTES

1. Opening in manhole cover provided for downstream valve only.
2. Blowoff pipe laid in excavation. Minimum slope of pipe .0025
3. Extension stems, guides and ladder are galvanized

CONSTRUCTION RECORD

Constructed July 12, 1925 to July 25, 1927 under Contract 7, Clifford F. MacElroy Co., Newark, N.J. Contractor, as shown on this record drawing.

Engineer in charge.

NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION

WANAQUE RESERVOIR
WOLF DEN DAM
BLOWOFF AT STATION 6+00

APRIL 30, 1931

Asst. Chief Engineer

FIGURE 3

Case C Dr12 File- 3.426 Wwd Acc. 325

2

APPENDIX A

VISUAL CHECKLIST

APPENDIX A - VISUAL INSPECTION CHECK LIST
PHASE 1

Name Dam: Wolf Den County: Passaic State: New Jersey Coordinators: Philadelphia District-Corps of Engineers

Date(s) Inspection: 9-11 May, 1978 Weather: Clear Temperature: 65°

Pool Elevation at Time of Inspection: 301.5 M.S.L. Tailwater at Time of Inspection: Not applicable

Inspection Personnel:
Gilbert Associates, Inc.

Fine T. Hsu
James A. Hagen
Rudolph J. Wahanik

Also Present:

Larry Woscyna (NJDEP)

James A. Hagen - Recorder

CONCRETE/MASONRY DAMS
(Dam is Earthfill)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Not Applicable	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not Applicable	
DRAINS	Not Applicable	
WATER PASSAGES	Not Applicable	
FOUNDATION	Not Applicable	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not Applicable	
STRUCTURAL CRACKING	Not Applicable	
VERTICAL AND HORIZONTAL ALIGNMENT	Not Applicable	
MONOLITH JOINTS	Not Applicable	
CONSTRUCTION JOINTS	Not Applicable	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	No significant sloughing or erosion of embankment and abutment slopes were observed. Trees growing on the downstream slopes were common. Trees were cut and removed in some areas in recent years. The clearing work is being continued.	All trees on the downstream slopes need to be removed.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical and horizontal alignment of the crest was generally in agreement with the record drawings.	
RIPRAP FAILURES	None observed.	Local minor irregularity and variation in riprap slopes probably resulted during the initial placement.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Junctions of all embankments and abutments appear to be in good and normal condition.	
ANY NOTICEABLE SEEPAGE	1 - Station 2+75 estimated flow 5 to 10 gpm, 10 ft beyond the toe of embankment at elevation 284, water clear.	None
	2 - Station 9+20 estimated flow 3 to 5 gpm, 5 ft to 16 ft beyond the toe, at elev. 273, water clear.	
	3 - Station 16+00 estimated flow 2 to 5 gpm, 6 ft to 10 ft beyond the toe at elev. 275, water clear.	
	4 - Station 17+45 estimated flow 3 gpm, 15 ft beyond the toe, at elevation 275.	
	5 - Station 22+70 estimated flow 2 to 5 gpm, 10 ft beyond the toe at elevation 285, water clear.	
STAFF GAGE AND RECORDER	None.	
DRAINS	A drainage pipe bulkhead at the toe of the embankment was found at station 6+00. Water was discharged at an estimated flow of 5 to 10 gpm through the pipe and the discharge water was clear.	It is likely that either the valve(s) was not completely shutoff or some leakage has occurred along the pipe system.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None observed.	None
INTAKE STRUCTURE	Not visible.	
OUTLET STRUCTURE	None.	
OUTLET CHANNEL	Acceptable.	
EMERGENCY GATE	Not Applicable	

UNGATED SPILLWAY - (NONE WAS OBSERVED)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Not Applicable	
APPROACH CHANNEL	Not Applicable	
DISCHARGE CHANNEL	Not Applicable	
BRIDGE AND PIERS	Not Applicable	

GATED SPILLWAY - (NONE WAS OBSERVED)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not Applicable	
APPROACH CHANNEL	Not Applicable	
DISCHARGE CHANNEL	Not Applicable	
BRIDGE AND PIERS	Not Applicable	
GATES AND OPERATION EQUIPMENT	Not Applicable	

INSTRUMENTATION (None was observed)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	Not Applicable	
OBSERVATION WELLS	Not Applicable	
WEIRS	Not Applicable	
PIEZOMETERS	Not Applicable	
OTHER	Not Applicable	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes around this part of the reservoir rim range from gentle to steep, and are formed by gneissic rock masses with little soil cover. The bank is also covered with trees or brush vegetation.	
SEDIMENTATION	Because of the geologic environment of Precambrian highlands, a thin soil cover in this region, and good vegetation cover around the reservoir, the amount of sedimentation deposited in the reservoir should be minimal and would accumulate at a very slow rate.	

APPENDIX B

ENGINEERING DATA CHECKLIST

APPENDIX B
CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	A tracing of the record drawing is available at the NJDWSC office in Wanaque, N.J. (hereafter referred to as NJDWSC-W)
REGIONAL VICINITY MAP	The USGS Wanaque, N.J. 7-1/2 min. quadrangle map is available.
CONSTRUCTION HISTORY	The 1925 Commissioner's Report (Reference 3) is available at NJDWSC-W. There is also a 1931 Commissioner's report at NJDWSC-W, an article on the construction was printed in the N.E.W.W.A. Journal (Reference 3) during construction. Some photos are available in the NJDWSC-W and the N.J. Dept. of Environmental Protection offices in Trenton, N.J. (DEP).
TYPICAL SECTIONS OF DAM	A section through the dam is shown on record drawing No. 49 of 61 which is available at NJDWSC-W (see page 13 of this report).
HYDROLOGIC/HYDRAULIC DATA	Records are available at NJDWSC-W and some are printed in USGS reports.
OUTLETS - PLAN	See attached sheet 51 in set 61
- DETAILS	See attach sheet 51 in set 61
- CONSTRAINTS	Not applicable.
- DISCHARGE RATINGS	Not applicable.
RAINFALL/RESERVOIR RECORDS	Excellent records are available from the USGS and NJDWSC from the time of construction of this dam.

APPENDIX B - CONT'D

ITEM	REMARKS
DESIGN REPORTS	Bid specifications are available at NJDWSC-W. Some design calculations are available in File #32 of the New Jersey Dept. of Environmental Protection offices in Trenton, N. J. (DEP). A brief description of the dam design appeared in the 1925 report (Reference 3, Chapter 11, pp. 51-52).
GEOLOGY REPORTS	Geologic reports of this dam site are not available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Design calculations, dam stability, or seepage studies were not available at NJDWSC-W. Complete original design calculations for this dam do not appear to be in the DEP files.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	There was no complete record of material investigations at NJDWSC-W, nor DEP, for this dam. There were some borings in general borrow areas, some foundation test borings, and foundation grouting data which is shown on the record drawings available at NJDWSC-W.
POST-CONSTRUCTION SURVEYS OF DAM	It appears that post construction survey information was used in preparing the record drawing.
BORROW SOURCES	Locations and logs of borrow areas are shown on contract drawings available at NJDWSC-W. The impervious borrow material for this dam apparently came from the floodplain or swampy areas near the dam.
SPILLWAY PLAN	Not Applicable
SECTIONS	Not Applicable
DETAILS	Not Applicable
OPERATING EQUIPMENT PLANS & DETAILS	Not Applicable

APPENDIX B - CONT'D

ITEM	REMARKS
MONITORING SYSTEMS	None observed.
MODIFICATIONS	No modifications from the design of the dam were observed.
HIGH POOL RECORDS	Records exist at the NJDWSC-W and USGS publications.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Annual reports for certain years are in dam file No. 32 of DEP.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported.
MAINTENANCE OPERATION RECORDS	Operational levels of the reservoir are available from NJDWSC-W.

APPENDIX B - CONT'D

CHECK LIST
ENGINEERING DATA
HYDROLOGIC AND HYDRAULIC DATA

DRAINAGE AREA CHARACTERISTICS: Densely forested, very hilly with minimal cover on bedrock.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 302.4 ft (61,531 Acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Not applicable

ELEVATION MAXIMUM SPILLWAY DESIGN FLOOD: 308.8

ELEVATION TOP DAM: 310.0

CREST: Cleared roadway

a. Elevation: 310.0
b. Type: Non-overflow
c. Width: 15 ft
d. Length: 2,200 ft
e. Location Spillover: Not applicable
f. Number and Type of Gates: Not applicable

OUTLET WORKS: Non-overflow

a. Type: Not applicable
b. Location: Not applicable
c. Entrance inverts: Not applicable
d. Exit inverts: Not applicable
e. Emergency draindown facilities: Not applicable

HYDROMETEOROLOGICAL GAGES: None at this dam

a. Type: Rainfall recording chart, 24 hour precipitation can, and maximum and minimum temperature recorder. Float type continuous stream level recorder with drum chart.

b. Location: Raymond Dam in Wanaque, New Jersey.

c. Records: Weather data published as climatological Data-Wanaque-Raymond Dam by the National Oceanic and Atmospheric Administration. Streamflow data is recorded by the U.S.G.S.

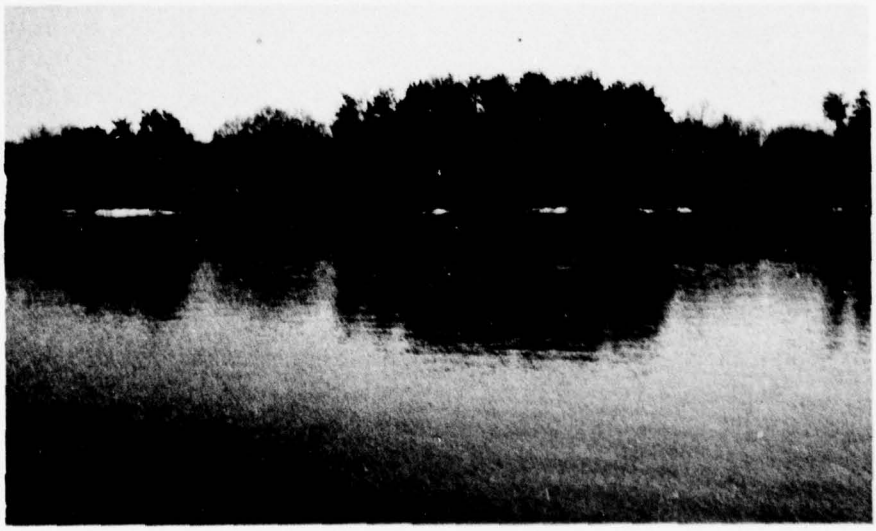
MAXIMUM NON-DAMAGING DISCHARGE: Non-overflow

APPENDIX C

PHOTOGRAPHS

May 1978

RECENTLY CLEARED SLOPE AREA



May 1978

EASTERLY SEGMENTS OF DAM FILLING BETWEEN ROCK OUTCROPS

APPENDIX D

RESERVOIR HYDROLOGY AND DRAWDOWN

APPENDIX D

RESERVOIR HYDROLOGY AND DRAWDOWN

Reservoir Hydrology

The hydrologic analyses presented in this Report and in the Appendix pertains to present hydrologic conditions and does not consider future changes produced by uncertain conditions such as urbanization, forest fires, or other modifications within the watershed.

The inflow Probable Maximum Flood Hydrograph for Wanaque Reservoir was supplied by the Philadelphia Office of the Corps of Engineers and is shown in Figure D-1 (Reference 8). This hydrograph has a peak flow rate of 33,500 cfs occurring 50 hours after its start. The total runoff volume is 94,500 acre-feet, over a time span of 140 hours. The HEC-1 Computer Program (Reference 5) was used to route this hydrograph through the reservoir. The main discharge structure for Wanaque Reservoir is a 520-ft long Overflow Weir about 0.2 mile east of Wolf Den Dam, which has had permanent flashboards in place since 1934. The storage volume-spillway outflow relation was determined assuming that the initial water surface elevation was at the top of the flashboards (302.4) and the structure functions as a sharp-crested weir.

The spillway discharge and the reservoir storage/spillway outflow relationships used in HEC-1 for routing the PMF and one-half PMF through the reservoir assume the flashboards are in place. These relationships are shown in Figure D-2.

Water Elevation (feet)	Spillway Discharge (cfs)	Reservoir Flood Storage (Acre-feet)
302.4	0	0
303	820	1,381
304	3,760	3,530
305	8,410	5,678
306	14,210	7,765
307	18,640	9,822
308	23,700	12,431
309	28,600	14,270
310	35,300	16,418

The surface area and storage of the Wanaque Reservoir at different water levels (Reference 2) are shown in Figure D-3. Their values are:

Water Elevation (feet)	Surface Area (Acres)	Storage (Acre-feet)
215	0	0
220	40	153
230	190	1,228
240	370	4,910
250	790	9,820
260	1,070	19,027
270	1,300	31,303
280	1,630	45,420
290	1,960	63,326
300	2,310	84,701
310*	2,620	106,183
312*	2,680	110,480

*Values extrapolated from elevation 305.00 ft. (Reference 2)

Results of this routing procedure indicate that the PMF would raise the pool elevation to about 308.8 ft. Routing one-half the PMF (16,750 cfs) through Wanaque Reservoir raises the pool elevation to about 306.0 ft, four feet below the crest of Wolf Den Dam.

Flood routing was also performed assuming that the flashboards were removed. In this case, the storage volume-outflow relation was determined with the starting water surface elevation at the top of the spillway crest (300.3 ft.) and the Overflow Weir discharging as an uncontrolled ogee crest spillway. HEC-1 results indicate that the PMF would raise the pool elevaton to 306.9 ft. The reservoir was designed to safely discharge 18,000 cfs (slightly larger than one-half of the PMF) without the flashboards in place. Graphs of pool elevation versus time for the PMF and one-half PMF routing, with and without flashboards, are found in Figures D-4 and D-5.

Reservoir Drawdown

If an emergency condition that affects the stability of one of several dams that form the Wanaque Reservoir or of the outlet and control works of the Raymond Dam develops, then a fast drawdown of the reservoir to a lower water level will be required. The lower water level depends on the

location and nature of the hazardous condition. Figure D-6 shows graphically the times required to lower the reservoir level with the existing facilities.

The water level in the Wanaque Reservoir can be lowered by the following means which are discussed further on the following pages.

A. The Wanaque Aqueduct System.

B. The existing aerator system.

C. A 36-inch diameter blowoff.

d. The blowoff and the aerator together.

e. Other blowoff lines.

All drawdown times were computed considering that the minimum inflow of 2 cfs/square mile into the reservoir was equalized by the system demand and other water loses.

A. The Wanaque Aqueduct

The potential of the Wanaque Aqueduct to lower the water level in the reservoir during an emergency condition is non-existent because a minimum inflow of two cfs per square mile, which is equivalent to 117 MGD, will supply the average daily demand of the distribution system. Table 1 gives the average water consumption during the last ten years.

Table 1

Year	Demand (MGD)
1967	95.37
1968	106.92
1969	111.17
1970	113.45
1971	112.88
1972	112.17
1973	103.09
1974	98.90
1975	92.07
1976	90.58
1977	107.01

B. Aerator System

Operation of the existing aerator system will drawdown the reservoir water level between the crest of the Overflow Weir at elevation 302.4 feet and the top of the aeration nozzles at elevation 240.5 feet in the following times:

Water Level (Feet)	Total Time (Days)
302.4	0.
300	10.39
290	55.42
280	98.03
270	135.76
260	174.69
250	212.65
240.5	253.65

C. 36-Inch Diameter Blowoff

The 36-inch diameter blowoff installed at the bottom of the Raymond Dam in the stream control conduits can be used to lower the reservoir level to an elevation of 222.00 feet which corresponds to the entrance intake sill to the lower conduit. The blowoff discharge is located at centerline elevation 213.38 feet. The times in days required by the blowoff line operating alone to lower the reservoir water level are:

Water Level (Feet)	Total Time (Days)
302.4	0.
300	33.18
290	177.59
280	309.41
270	420.21
260	525.48
250	613.40
240	677.29
230	713.89
222	728.79

D. Blowoff and Aerator

Simultaneous operation of the 36-inch diameter blowoff pipe and with the aerator system will lower the reservoir level in the following times:

Water Level (Feet)	Total Time (Days)
302.4	0.
300	7.95
295	42.28
280	74.48
270	102.63
260	131.05
250	157.55
240	181.98
230	218.58
222	233.48

E. Other Blowoff Lines

Smaller diameter blowoff lines installed in several of the dams around the Wanaque Reservoir are not known to be in operable condition because, since their installation in 1925, the lines have not been inspected, operated, or maintained.

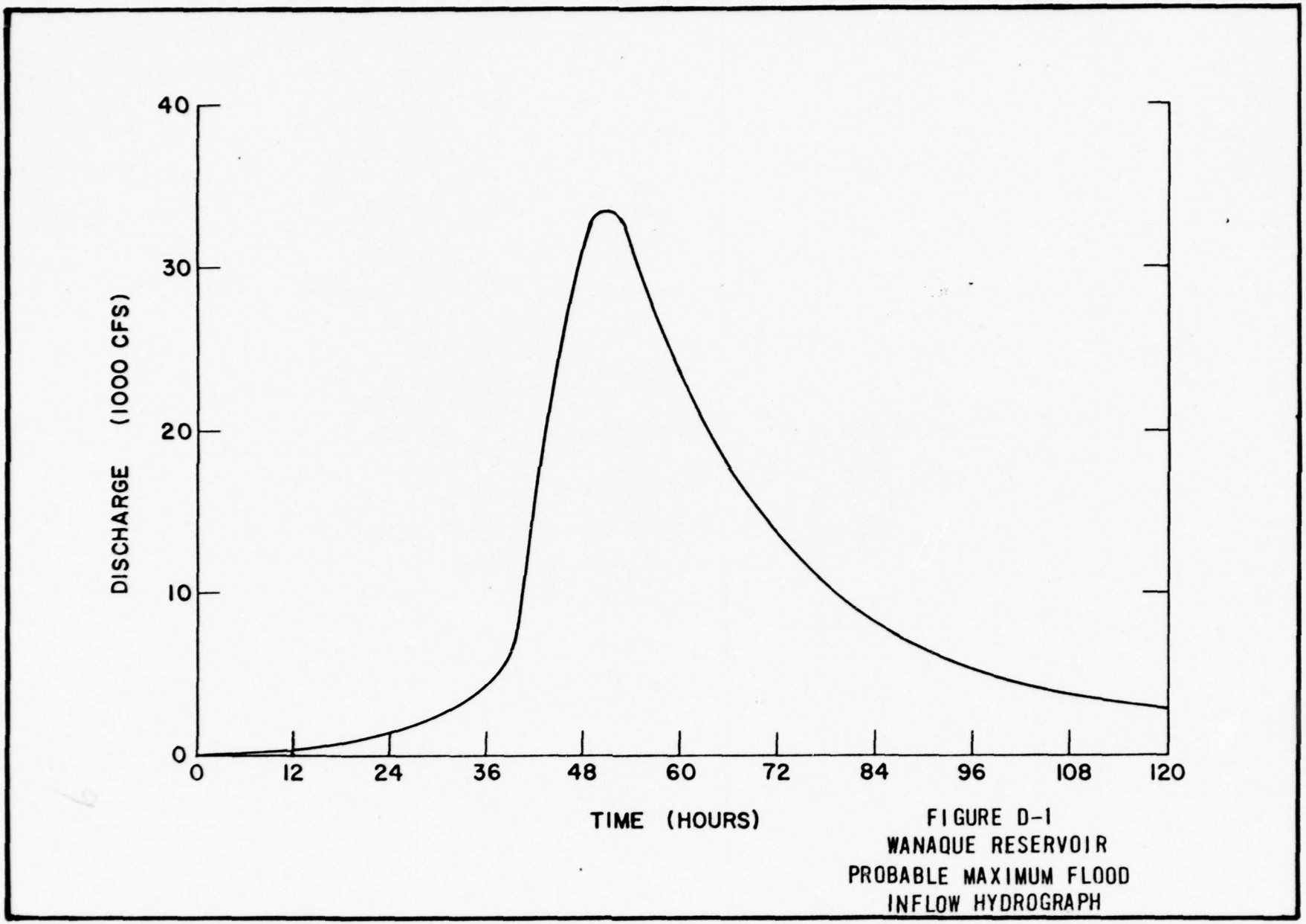


FIGURE D-1
WANAQUE RESERVOIR
PROBABLE MAXIMUM FLOOD
INFLOW HYDROGRAPH

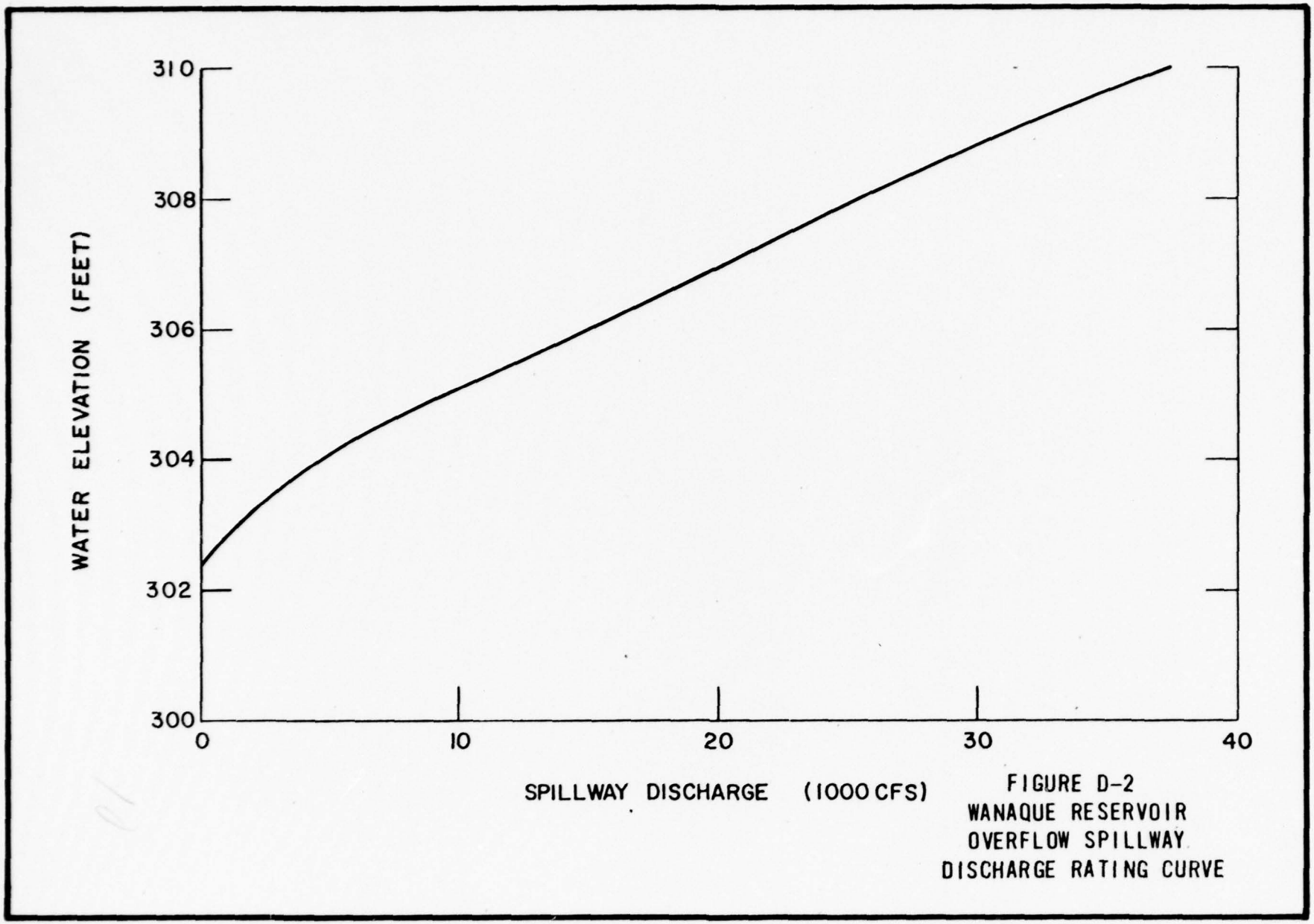


FIGURE D-2
WANAQUE RESERVOIR
OVERFLOW SPILLWAY
DISCHARGE RATING CURVE

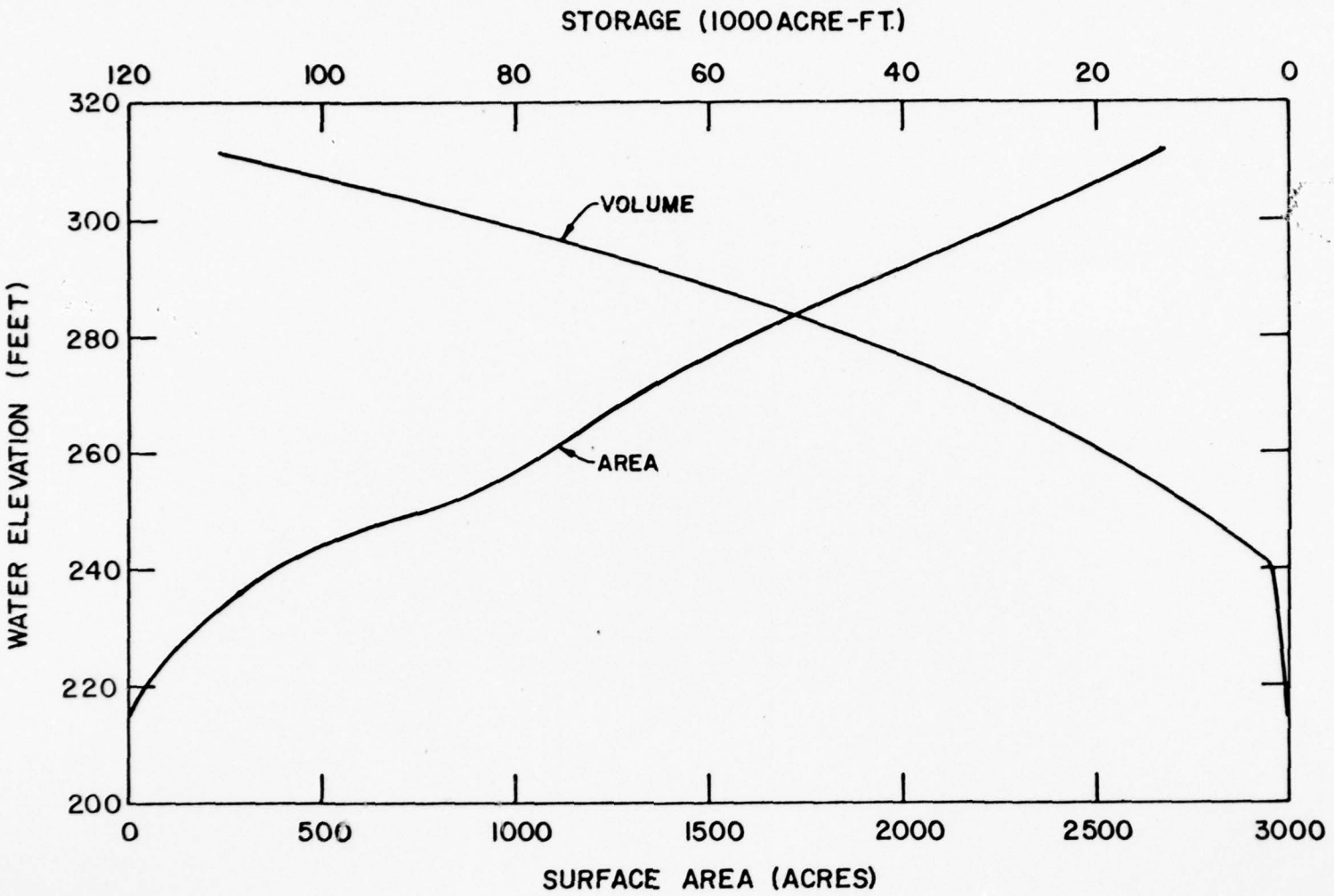


FIGURE D-3
WANAQUE RESERVOIR
AREA - CAPACITY CURVES

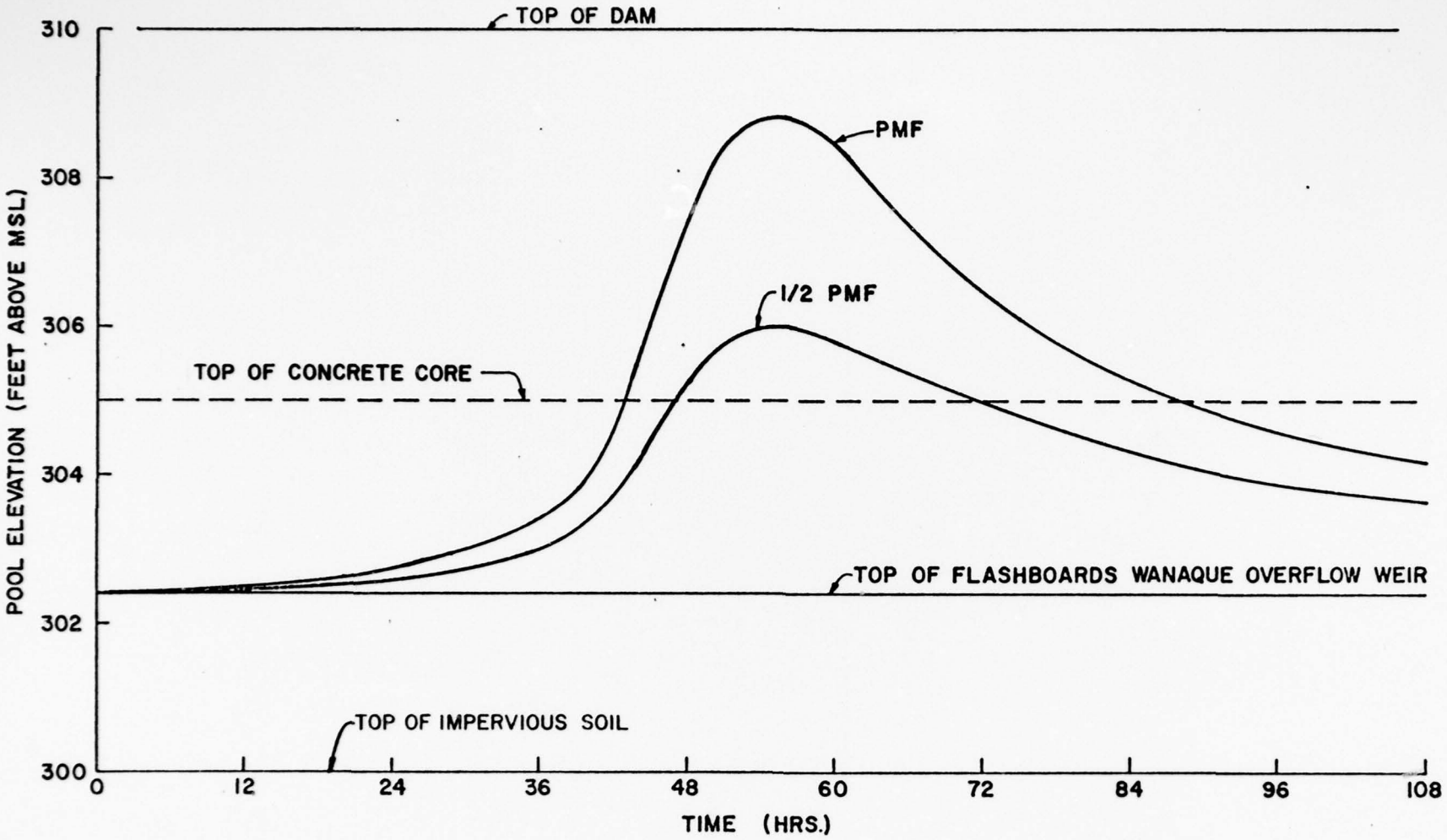


FIGURE D-4
FLOOD ROUTING THROUGH
WANAQUE RESERVOIR WITH
FLASHBOARDS IN PLACE

WOLF DEN DAM

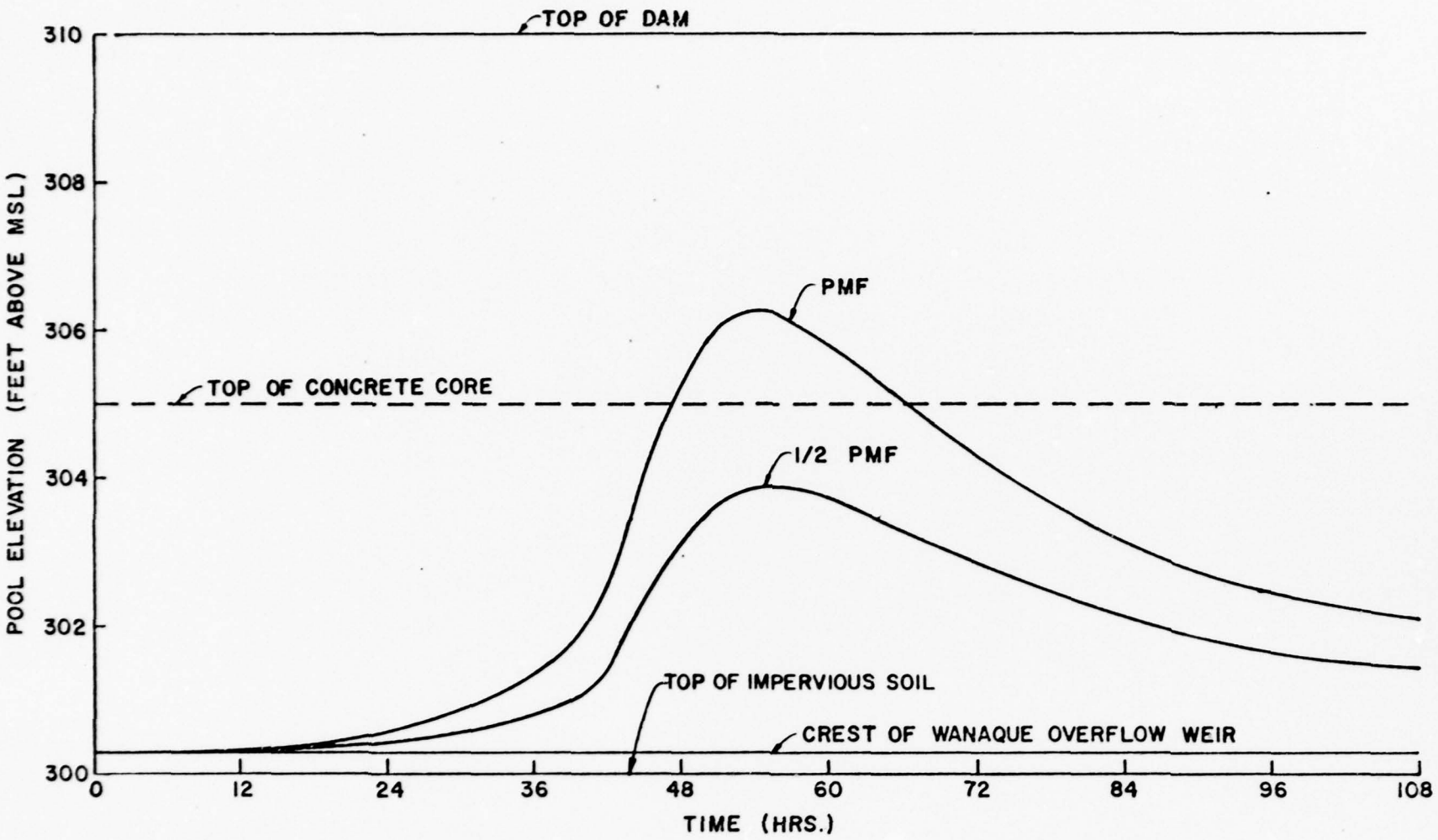


FIGURE D-5
FLOOD ROUTING THROUGH
WANAQUE RESERVOIR WITHOUT
FLASHBOARDS IN PLACE

WOLF DEN DAM

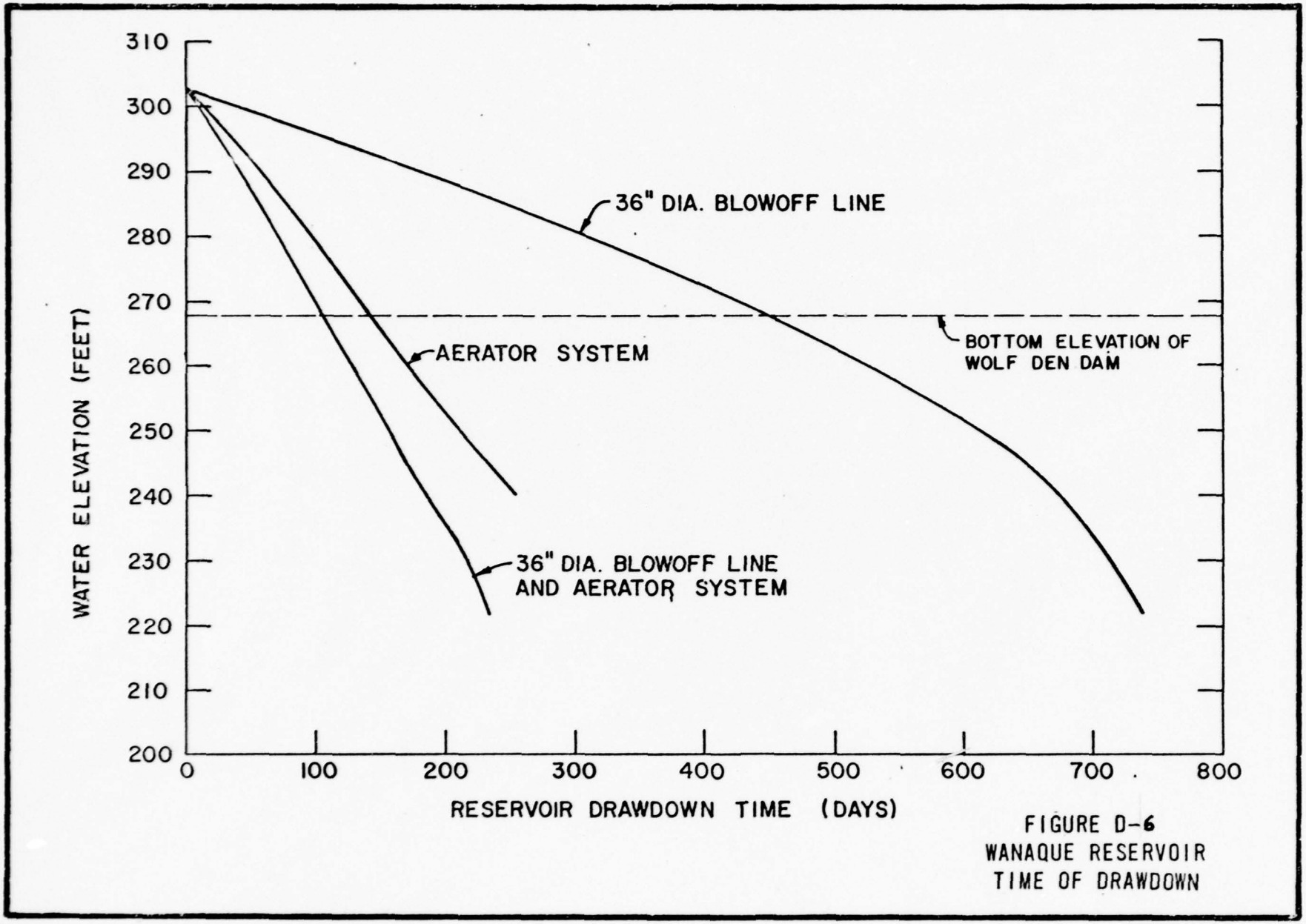


FIGURE D-6
WANAQUE RESERVOIR
TIME OF DRAWDOWN

6000 REMOTE BATCH

M2E2FAJ

UNITED COMPUTING 67. APEX/SL D.1.5

12.52.08. 06/08/78.

WANAQUE RESERVOIR FLOOD ROUTING

BRIDGE REMAINS IN PLACE

1) PMF WITH FLASHBOARDS

2) ½ PMF WITH FLASHBOARDS

3) PMF WITHOUT FLASHBOARDS

4) ½ PMF WITHOUT FLASHBOARDS

```
**********
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
**********
```

HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

FLOOD ROUTING THROUGH WANAQUE RESERVOIR - NEW JERSEY
OVERFLOW WEIR WITH FLASHBOARDS
PROBABLE MAXIMUM FLOOD

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
70	2	-0	1	-0	-0	-0	-0	-0	-0

JOPER	NWT
3	-0

SUB-AREA RUNOFF COMPUTATION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	-0	-0	-0	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	-0	90.40	-0.00	-0.00	-0.00	-0.000	-0	-0	-0

INPUT HYDROGRAPH

0.	100.	200.	300.	400.	500.	600.	700.	800.	900.
1100.	1300.	1500.	1800.	2200.	2600.	3400.	4600.	7000.	10500.
19600.	26200.	29600.	32200.	33500.	32000.	28300.	26500.	24000.	21800.
19700.	18000.	16500.	15000.	13800.	12600.	11500.	10600.	9800.	9000.
8300.	7700.	7100.	6600.	6200.	5800.	5400.	5000.	4700.	4400.
4200.	4000.	3800.	3600.	3400.	3200.	3100.	3000.	2900.	2800.
2700.	2600.	2500.	2500.	2500.	2500.	2500.	2500.	2500.	2500.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	33500.	32567.	25950.	14042.	571200.
INCHES		3.35	10.68	17.34	19.59
AC-FT		16157.	51498.	83597.	94462.

HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	1	-0	-0	2	-0	-0

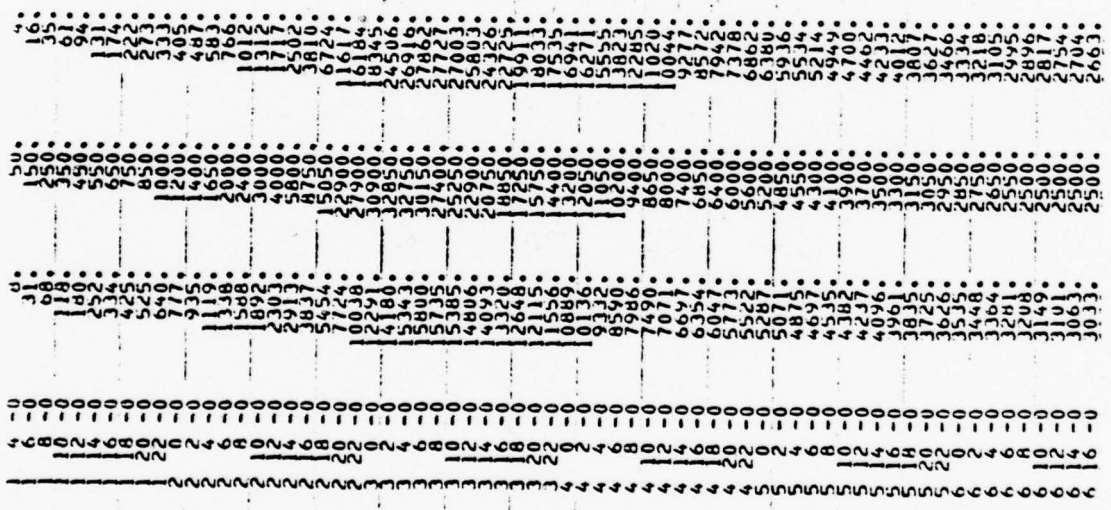
ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
-0.0	-0.000	-0.00	1	-0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
-0	-0	-0	-0.000	-0.000	-0.000	-1.

STORAGE=	0.	1190.	2387.	3592.	4805.	7254.	9236.	12247.	13260.	15046.
OUTFLOW=	0.	620.	1800.	3410.	5390.	10420.	15470.	18150.	22600.	26300.

TIME EOP STOR AVG IN EOP OUT

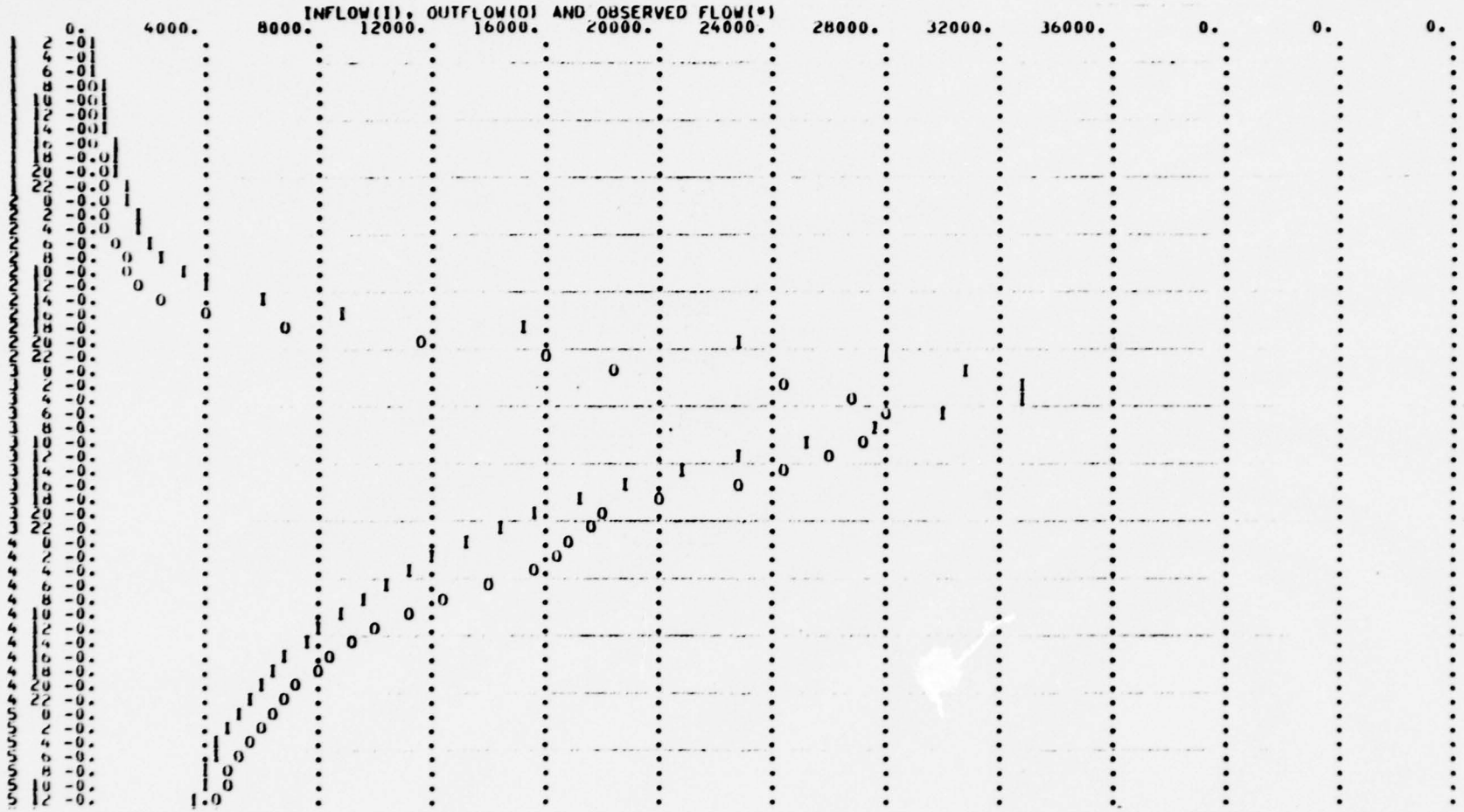


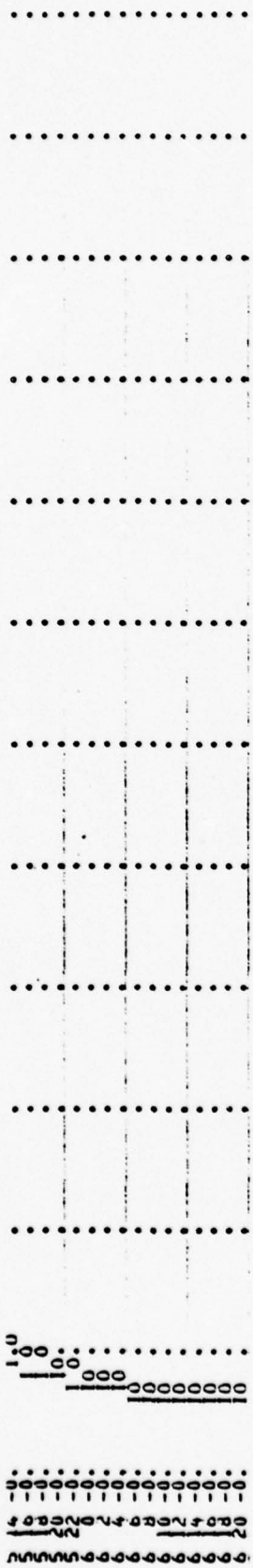
6 20 -0	2989.	2500.	2605.
SUM			553167.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	27862.	27530.	23391.	13795.	553167.
INCHES		2.83	9.63	17.03	18.97
AC-FT		13658.	46419.	82126.	91480.

OVF

STATION 1





RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	33500.	32567.	25950.	14042.	90.40
ROUTED TO	1	27862.	27530.	23391.	13795.	90.40

****
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
****

FLOOD ROUTING THROUGH WANAQUE RESERVOIR - NEW JERSEY
OVERFLOW WEIR WITH FLASHBOARDS
ONE-HALF THE PROBABLE MAXIMUM FLOOD

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
70	2	-0	1	-0	-0	-0	-0	-0	-0

JOPER	NWT
3	-0

****

SUB-AREA RUNOFF COMPUTATION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	-0	-0	-0	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	-0	90.40	-0.00	-0.00	-0.00	-0.000	-0	-0	-0

INRUT HYDROGRAPH

0.	50.	100.	150.	200.	250.	300.	350.	400.	450.
550.	650.	750.	900.	1100.	1300.	1700.	2300.	3500.	5250.
9800.	13100.	14800.	16100.	16750.	16000.	14150.	13250.	12000.	10900.
9850.	9000.	8250.	7500.	6900.	6300.	5750.	5300.	4900.	4500.
4150.	3850.	3550.	3300.	3100.	2900.	2700.	2500.	2350.	2200.
2100.	2000.	1900.	1800.	1700.	1600.	1550.	1500.	1450.	1400.
1350.	1300.	1250.	1250.	1250.	1250.	1250.	1250.	1250.	1250.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16750.	16283.	12975.	7021.	285600.
INCHES		1.68	5.34	8.67	9.80
AC-FT		80791	25749.	41798.	47231.

****

HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	1	-0	-0	2	-0	-0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
-0.0	-0.000	-0.00	1	-0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
-0	-0	-0	-0.000	-0.000	-0.000	-1.

STORAGE=	0.	1190.	2387.	3592.	4805.	7254.	9236.	12247.	13260.	15046.
OUTFLOW=	0.	620.	1800.	3410.	5390.	10420.	15470.	18150.	22600.	26300.

TIME EOP STOR AVG IN EOP OUT

1	4 -0	4.	25.	2.
1	6 -0	16.	75.	8.
1	8 -0	34.	125.	18.
1	10 -0	59.	175.	31.
1	12 -0	90.	225.	47.
1	14 -0	126.	275.	66.
1	16 -0	167.	325.	87.
1	18 -0	213.	375.	111.
1	20 -0	262.	425.	137.
1	22 -0	320.	500.	167.
2	0 -0	389.	600.	203.
2	2 -0	468.	700.	244.
2	4 -0	560.	825.	292.
2	6 -0	672.	1000.	350.
2	8 -0	807.	1200.	420.
2	10 -0	978.	1500.	509.
2	12 -0	1213.	2000.	643.
2	14 -0	1558.	2900.	983.
2	16 -0	2077.	4375.	1494.
2	18 -0	2982.	7525.	2595.
2	20 -0	4285.	11450.	4541.
2	22 -0	5630.	13950.	7085.
3	0 -0	6812.	15450.	9512.
3	2 -0	7771.	16425.	11737.
3	4 -0	8404.	16375.	13350.
3	6 -0	8640.	15075.	13950.
3	8 -0	8605.	13700.	13863.
3	10 -0	8426.	12625.	13433.
3	12 -0	8166.	11450.	12743.
3	14 -0	7842.	10375.	11919.
3	16 -0	7502.	9425.	11051.
3	18 -0	7168.	8625.	10243.
3	20 -0	6833.	7875.	9555.
3	22 -0	6500.	7200.	8872.
4	0 -0	6179.	6600.	8212.
4	2 -0	5870.	6025.	7578.
4	4 -0	5580.	5525.	6982.
4	6 -0	5314.	5100.	6436.
4	8 -0	5069.	4700.	5932.
4	10 -0	4642.	4325.	5466.
4	12 -0	4629.	4000.	5104.
4	14 -0	4425.	3700.	4770.
4	16 -0	4229.	3425.	4450.
4	18 -0	4047.	3200.	4153.
4	20 -0	3879.	3000.	3879.
4	22 -0	3722.	2800.	3622.
5	0 -0	3573.	2600.	3384.
5	2 -0	3430.	2425.	3194.
5	4 -0	3293.	2275.	3011.
5	6 -0	3165.	2150.	2840.
5	8 -0	3048.	2050.	2683.
5	10 -0	2939.	1950.	2537.
5	12 -0	2836.	1850.	2400.
5	14 -0	2739.	1750.	2271.
5	16 -0	2647.	1650.	2147.
5	18 -0	2562.	1575.	2034.
5	20 -0	2486.	1525.	1932.
5	22 -0	2418.	1475.	1841.
6	0 -0	2355.	1425.	1769.
6	2 -0	2295.	1375.	1709.
6	4 -0	2236.	1325.	1651.
6	6 -0	2179.	1275.	1595.
6	8 -0	2126.	1250.	1543.
6	10 -0	2081.	1250.	1499.
6	12 -0	2043.	1250.	1461.
6	14 -0	2011.	1250.	1429.
6	16 -0	1984.	1250.	1402.

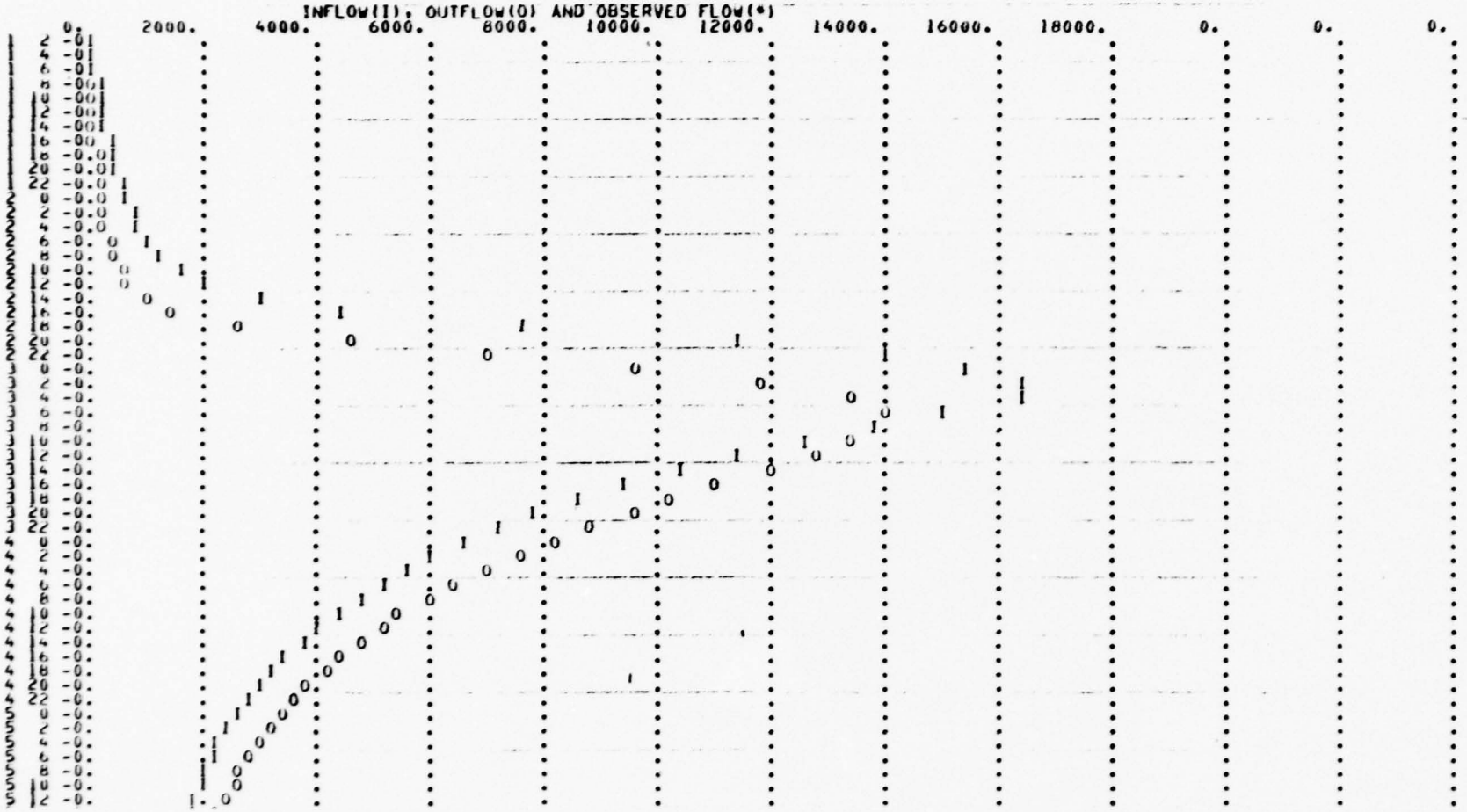
6 18 -0	1460.	1450.	1379.		
6 20 -0	1941.	1250.	1360.		
SUM			273915.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13950.	13749.	11686.	6819.	273915.
INCHES		1.41	4.81	8.42	9.40
AC-FT		6821.	23190.	40599.	45298.

OVF

STATION 1

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)




NAD

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	16750.	16283.	12975.	7021.	90.40
ROUTED TO	1	13950.	13749.	11686.	6819.	90.40

****
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
****

FLOOD ROUTING THROUGH WANAQUE RESERVOIR - NEW JERSEY
OVERFLOW WEIR WITHOUT FLASHBOARDS
PROBABLE MAXIMUM FLOOD

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
70	2	-0	1	-0	-0	-0	-0	-0	-0

JOPER 3 NWT -0

****

SUB-AREA RUNOFF COMPUTATION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	-0	-0	-0	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	-0	90.40	-0.00	-0.00	-0.00	-0.000	-0	-0	-0

INPUT HYDROGRAPH

0.	100.	200.	300.	400.	500.	600.	700.	800.	900.
1100.	1300.	1500.	1800.	2200.	2600.	3400.	4600.	7000.	10500.
19600.	26200.	29600.	32200.	33500.	32000.	28300.	26500.	24000.	21800.
19700.	18000.	16500.	15000.	13800.	12600.	11500.	10600.	9800.	9000.
8300.	7700.	7100.	6600.	6200.	5800.	5400.	5000.	4700.	4400.
4200.	4000.	3800.	3600.	3400.	3200.	3100.	3000.	2900.	2800.
2700.	2600.	2500.	2500.	2500.	2500.	2500.	2500.	2500.	2500.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	33500.	32567.	25950.	14042.	571200.
INCHES		3.35	10.68	17.34	19.59
AC-FT		16157.	51498.	83597.	94462.

****

HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	1	-0	-0	2	-0	-0

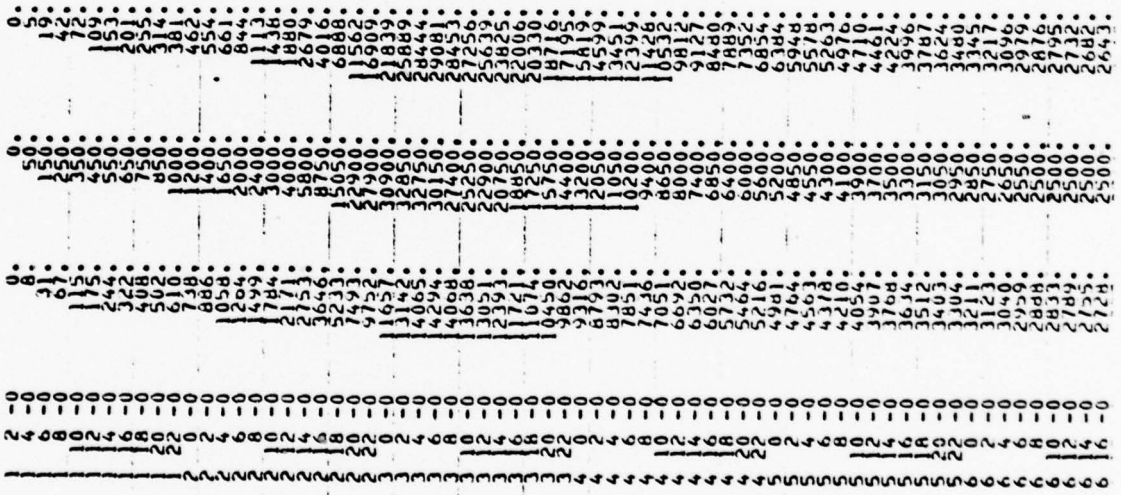
ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
-0.0	-0.000	-0.00	1	-0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA
-0	-0	-0	-0.000	-0.000	-0.000	-1.

STORAGE=	0.	1160.	2320.	3490.	4670.	7060.	9470.	11920.	13650.	14150.
OUTFLOW=	0.	725.	2050.	3750.	5760.	10550.	16180.	22520.	27290.	28680.

TIME EOP STOR AVG IN EOP OUT



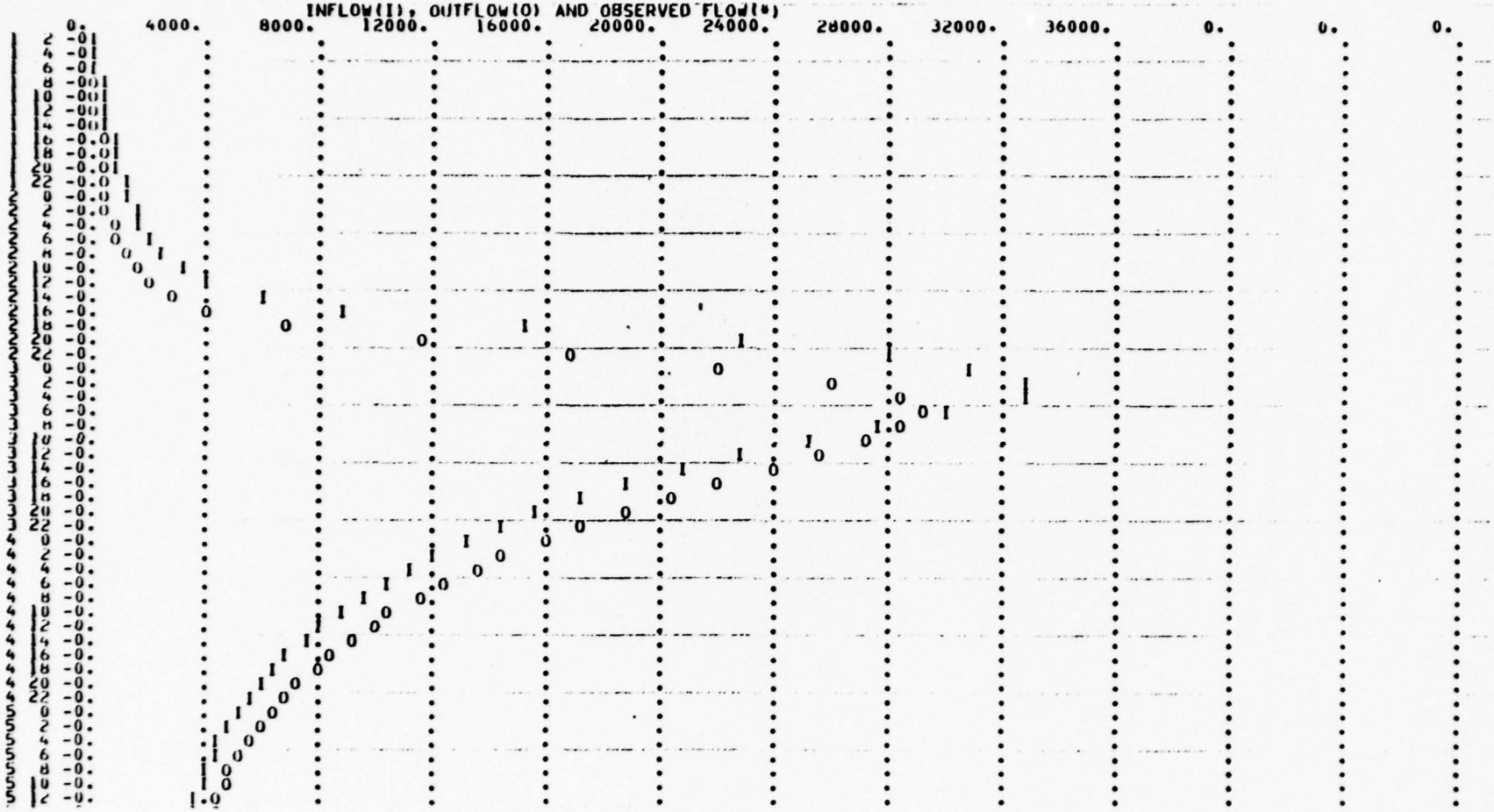
6 18 -0	2707.	2500.	2588.	
6 20 -0	2691.	2500.	2588.	
SUM			554967.	

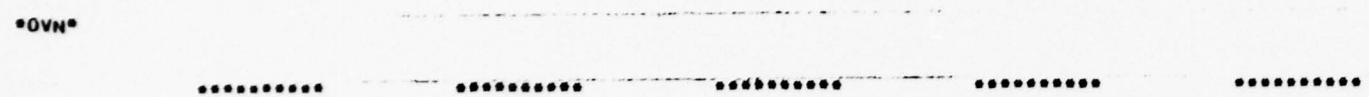
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	29081.	28659.	24056.	13815.	554967.
INCHES		2.95	9.90	17.06	19.04
AC-FT		14219.	47739.	82246.	91777.

OVF

STATION 1

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)




•OVN•

RUNOFF SUMMARY, AVERAGE FLOW

	PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	33500.	32567.	25950.	14042.	90.40
ROUTED TO	29081.	28659.	24056.	13815.	90.40

****
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
****

FLOOD ROUTING THROUGH WANAQUE RESERVOIR - NEW JERSEY
OVERFLOW WEIR WITHOUT FLASHBOARDS
ONE-HALF THE PROBABLE MAXIMUM FLOOD

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
70	2	-0	1	-0	-0	-0	-0	-0	-0

JOPER	NWT
3	-0

****

SUB-AREA RUNOFF COMPUTATION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	-0	-0	-0	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	-0	90.40	-0.00	-0.00	-0.00	-0.000	-0	-0	-0

INPUT HYDROGRAPH

0.	50.	100.	150.	200.	250.	300.	350.	400.	450.
550.	650.	750.	900.	1100.	1300.	1700.	2300.	3500.	5250.
9800.	13100.	14800.	16100.	16750.	16000.	14150.	13250.	12000.	10900.
9850.	9000.	8250.	7500.	6900.	6300.	5750.	5300.	4900.	4500.
4150.	3850.	3550.	3300.	3100.	2900.	2700.	2500.	2350.	2200.
2100.	2000.	1900.	1800.	1700.	1600.	1550.	1500.	1450.	1400.
1350.	1300.	1250.	1250.	1250.	1250.	1250.	1250.	1250.	1250.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16750.	12983.	12975.	7021.	285600.
INCHES		1.68	5.34	8.67	9.80
AC-FT		80794	25749.	41798.	47231.

****

HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	1	-0	-0	2	-0	-0

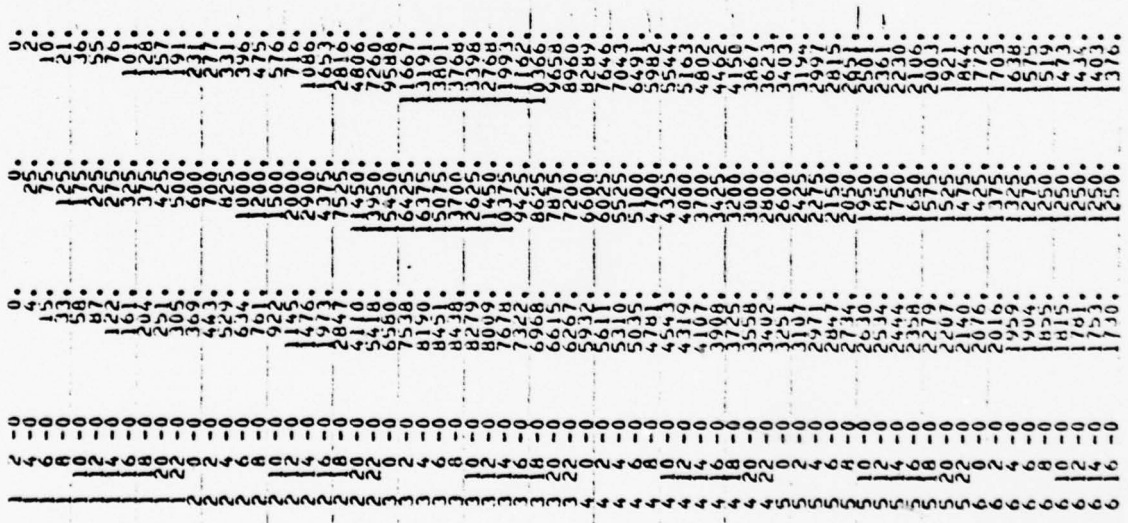
ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
-0.0	-0.000	-0.00	1	-0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
-0	-0	-0	-0.000	-0.000	-0.000	-1.

STORAGE=	0.	1160.	2320.	3490.	4670.	7060.	9470.	11920.	13650.	14150.
OUTFLOW=	0.	725.	2050.	3750.	5760.	10550.	16180.	22520.	27290.	28680.

TIME EOP STOR AVG IN EOP OUT



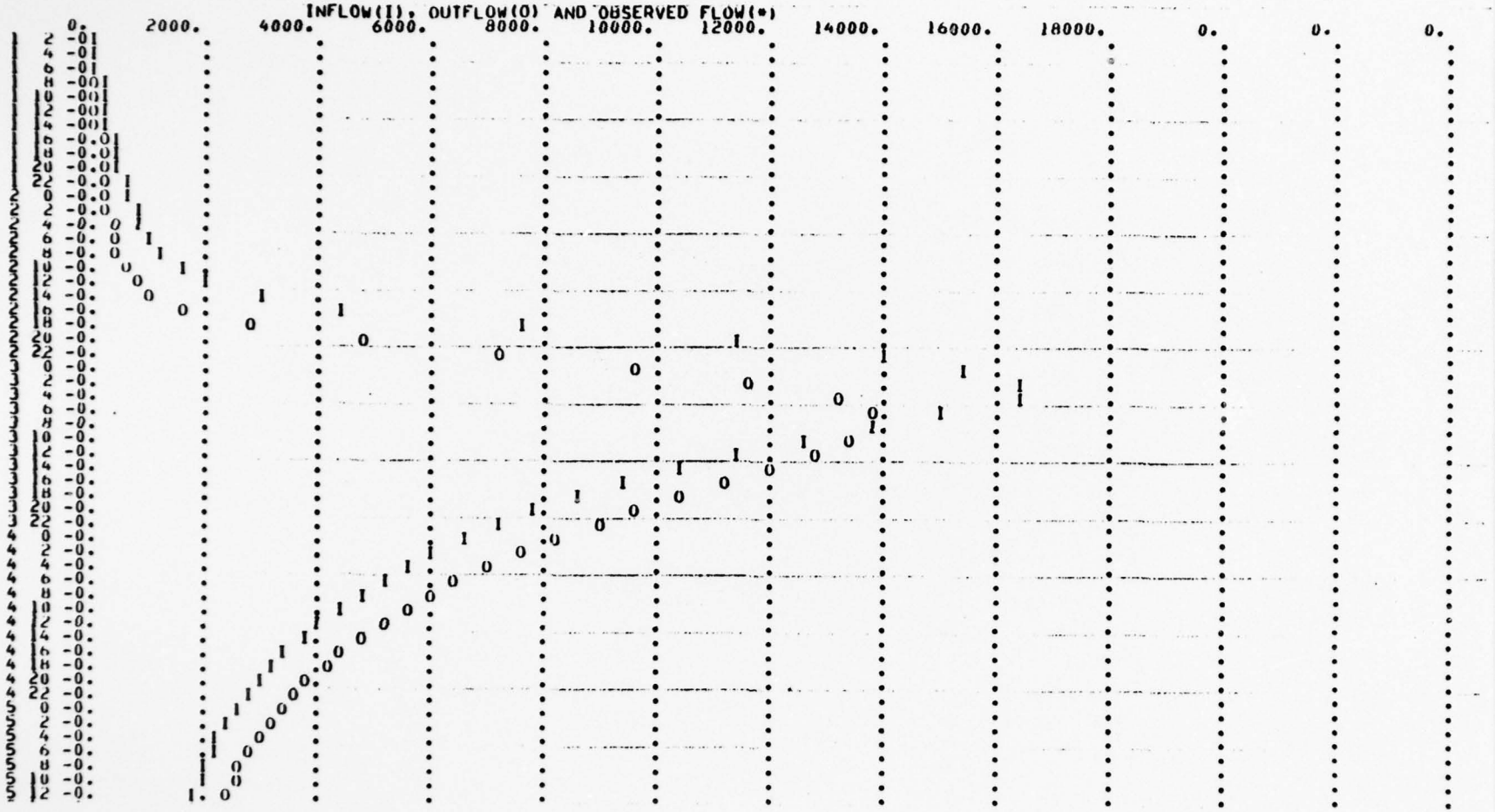
6 18 -0	1711.	1250.	1354.		
6 20 -0	1695.	1250.	1336.		
SUM			275387.		

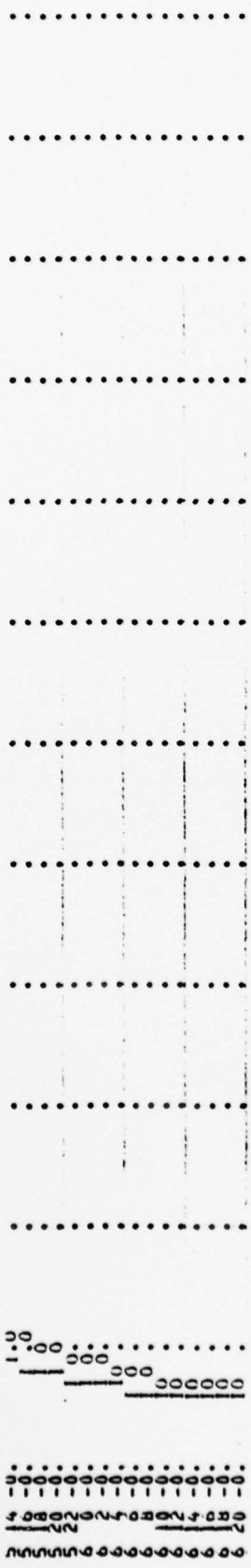
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13801.	13656.	11693.	6848.	275387.
INCHES		1.41	4.81	8.46	9.45
AC-FT		6775.	23205.	40768.	45542.

OVF

STATION 1

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)





RUNOFF SUMMARY: AVERAGE FLOW

	PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	16750.	6283.	2975.	7021.	90.40
ROUTED TO	13401.	3656.	1693.	6848.	90.40

M2E2FAJ. 06/08/78. *UNITED COMPUTING* 67. APEX/SL D.1.5

```
2.49.| 2$RAQUE,CM100000,T20,  RAP 6547 067249000
2.49.| 2.0674 4695 UCS
2.49.| 3$AC3400G32A303,067249000 .B
2.49.| 3. 06/08/78.M2E2FAJ
2.49.| 3$FL     32768       0.002          5          3,
2.49.| 3$FT          0             1
2.49.| 3.GET,MEC1/UN=LIBRARY)
2.49.| 4.READY -    MEC1
2.49.| 4.MFL,150000,
2.49.| 4$FL      4096       0.002          0          0,
2.49.| 4$FT          0             1
2.49.27.MEC1.
2.49.27$FLS   5324A       0.002
2.49.29$FLR   5324A       0.190        349         18
2.49.29.FL REQUIRED TO LOAD    141322B ( 49874)
2.49.29.FL REQUIRED TO EXECUTE 123700B ( 42944)
2.49.29$FL    5324A       0.202
2.49.35.STOP
2.49.35.GOEXIT.
2.49.35. ILLEGAL CONTROL CARD.
2.49.35.EXIT.
2.49.35$SB*   42944       1.326        773         66
2.49.35.COST.
2.49.35$FL    42944       1.327
2.49.35.          SERV. UNITS-2 =       12
2.49.35.          JOB COST=$          3.00
2.49.35$JTOJ  12288       1.345          7          5
2.49.35.    *FL*  *CPU SEC. *DISC PRUS* DISC ACC
2.49.35.* LDR PRUS*P.F. ACC *TAPE PRUS* TAPE ACC
```

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-H

12 MAY 1978

Mr. Robert A. Putt
Hydraulic Engineer
Gilbert Associates, Inc.
P. O. Box 1498
Reading, PA 19603

Dear Mr. Putt:

The following information is to be applied when determining the Spillway Design Flood for the first nine dams Gilbert/Commonwealth is inspecting in connection with the Dam Safety Program.

For the five dams around the Wanaque Reservoir (Raymond, Wolf Den, Furnace Road, Midvale and the Overflow Weir), the hydrograph used should conform to the data specified below:

Peak Q= 33,500 cfs

Shape should be similar to the PMF hydrograph labeled "Wanaque River at Mouth MPF=29,300 cfs SPF = 14,000 cfs shown on Figure A63 of the Passaic River Basin Report. (A copy of this figure is inclosed)

The above information is from the Passaic River Basin-New Jersey and New York Survey Report for Water Resources dated June 1972 by the New York District Corps of Engineers. The drainage area above the Wanaque Dam stated in this report is slightly different than the drainage area you have supplied to us in your letter dated 9 May 1978. To maintain consistency between reports we would suggest using 90.4 sq. mi. for the drainage area above the Wanaque Reservoir as published in Table A1 of the Passaic River Basin Report.

Due to the small drainage area of the remaining four dams (Glen Wild Lake -1.04 sq. mi., Lake Vreeland-0.83 square mi., Crystal Lake-4.34 sq. mi., and Cedar Grove Reservoir-0.45 Sq. mi.), the hydrographs for these dams should be developed using the SCS triangular method. For an example of this method see Pg. 74 of Design of Small Dams (second edition) by the U. S. Department of Interior-Bureau of Reclamation.

NAPEN-H
Mr. Robert A. Putt

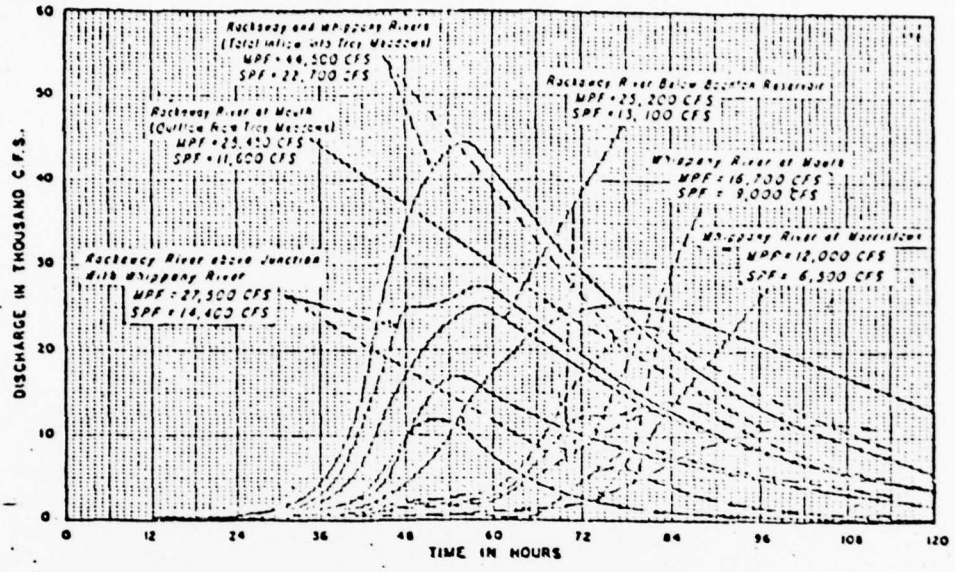
If there are any other questions, please do not hesitate to contact us.

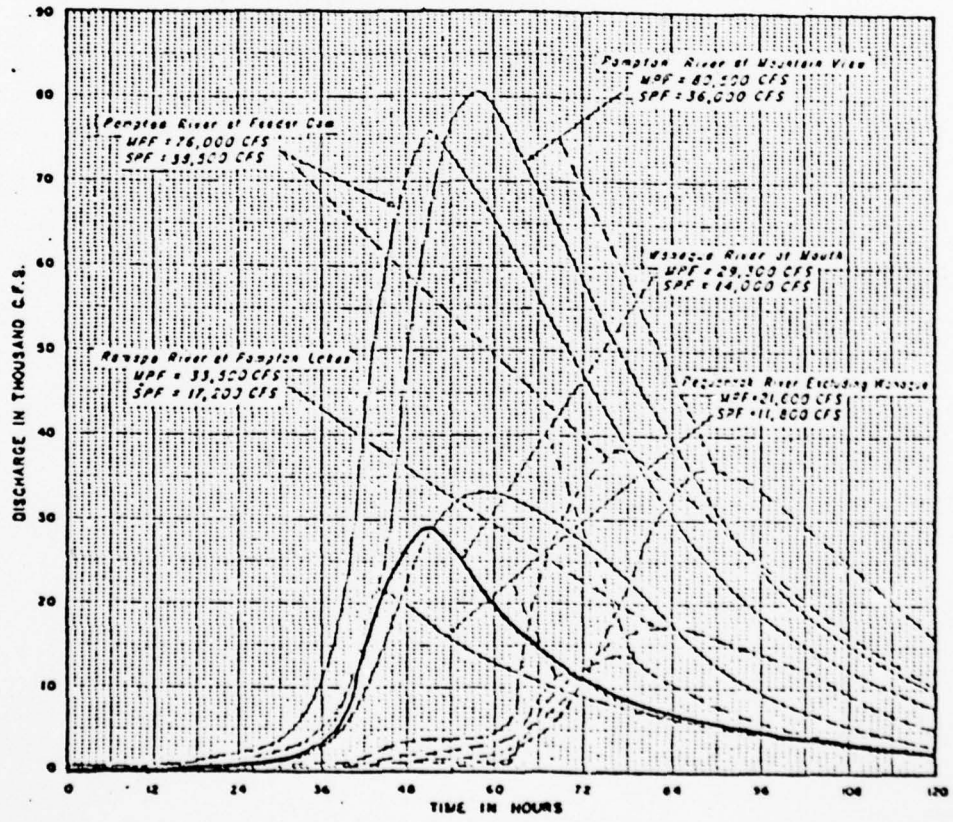
Sincerely yours,

Leonard J. Lipski

LEONARD J. LIPSKI
Chief, Hydrology-Hydraulics Branch

1 Incl
Fig. A63 (Passaic River
Basin Report)





PASSAIC RIVER BASIN, N. J. AND N. Y.
STANDARD PROJECT AND
MAXIMUM PROBABLE FLOODS
(EXISTING CONDITIONS WITH
RAINFALL OVER ENTIRE BASIN ABOVE
PATERSON, N.J.)

FIGURE A03

APPENDIX E

INSPECTION REPORTS

(The North Jersey District Water Supply Commission provided the inspection reports contained herein.)

NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION

MEMORANDUM

TO: Dam Inspection File

FROM: Joseph Foley, Engineer

DATE: April 5, 1977

On March 31, 1977 Roscoe Jennings, Doug De Lorie and I inspected the dams at the Wanaque Reservoir; the following is a report on their conditions and recommendations on maintenance of same.

FURNACE ROAD DAM

Condition: There are trees and brush on the wet and dry sides of the dam and also a small swamp of apparently trapped water behind the dam.

Recommendations: The trees should be killed and removed using poison suitable for potable water.

MIDVALE DAM

Condition: Some trees are growing on the wet and dry sides of the dam. There is a small spring flowing from the foot of the dam at the north end. Wet spots and soft wet sand are also apparent at the foot of the dam. No sink holes or other indications of dam failure were apparent at this location. A sample of water from this spring and a sample from the reservoir were taken and anlyzed, the results are as follows:

Spring Water:	Specific conductivity	68
	pH	6.3
Reservoir Water:	Specific conductivity	102
	pH	6.9

The results indicate that this water is more likely to be ground water than reservoir water. (For additional information, please refer to a memo from Bob Wieland to George Destito dated May 3, 1976).

Recommendations: The trees on the dam should be killed and removed. The dam should also be checked periodically to be sure the spring is not a leak in the dam.

RAYMOND DAM

Condition: Excellent

SPILLWAY

Condition: Good, except that it was indicated by Ernie Restaino that there is a small leak in the spillway. I did not observe it because of the overflow. I will check it again when the reservoir goes down.

Recommendations: The leak in the spillway should be fixed when the reservoir goes down.

WOLF DEN DAM

Condition: There are trees and shrubs on both the wet and dry sides. There are small springs flowing from the low sections behind the dam. Some samples were also taken here and the results were that the water had a specific conductivity of 90 and a pH of 6.3, so this water is most likely ground water also.

Recommendations: I recommend that the trees and shrubs be removed.

GREEN SWAMP

#4 Dam

Condition: The general condition of the dam is good, although sections of the gunite surfacing are cracked and have fallen off (especially near the expansion joints), due to moisture that found its way under the guite. There was water running out of the drain but this flow was not excessive.

Recommendations: The cracked and loose gunite should be chipped away and replaced and at the expansion joints, the gunite should be chipped and tar poured in to allow expansion of the concrete.

#3 and #2A Dams

Condition: Both small dams are heavily wooded and there is a small swamp behind the #3 dam.

Recommendations: The only recommendation for these dams is that the trees be removed from both sides of the dams.

#2 Dam

Condition: This dam is in excellent condition, except around the expansion joints where the gunite is cracked due to the fact that no allowance was made for expansion when the guite was applied to the dam. There is also a swamp behind this dam, but this looks like a natural swamp.

Recommendations: The gunite at the expansion joints should be chipped away and tar poured in to allow expansion and any other cracks in the gunite should be chipped and repaired.

#1 Dam

Condition: There are trees and shrubs on both wet and dry sides of this dam. There is also a swamp behind the dam.

Recommendations: The dam should be cleared of trees and shrubs.

As a result of my research, so far on dam inspection, I received a booklet, "Supervision of Dams by State Authorities" published by the United States Committee on large dams, July 1966. This publication had little information on the actual inspection of dams but it did have some useful information such as: the function of dam supervision in New Jersey is performed by the Chief Engineer, Division of Water Policy and Supply, Department of Conservation and Economic development. Inspection of dams is done by the State at the State's own expense on the complaint of potential failure.

Additional information on dam inspection is also coming from the Corps of Engineers and the United States Committee on Large Dams.

JF:lk

cc: Dean C. Noll
Robert G. Wieland

Report on Dam Inspection

WANAQUE PROJECT

Application No. 32.

Location 23.31.5.4.3 and nearby.

On March 23, 1928, the gates in the main dam were closed except for the passage of 27 m. g. d. through the blow-off, and on March 29, 1928, the water in the reservoir had risen 7 feet.

On March 29, 1928, in company with Mr. H. T. Critchlow, inspection was made of all of the dams in the Wanaque project.

Furnace Road dam was found to be about 50 per cent complete.

Post Brook Diversion dam, weir and control house were complete except for closing a small breach which was left in the dam for stream control, and installation of recording gage in the control house.

Wanaque Main dam.

Midvale Dam.

Overflow Weir.

Wolf Den Dam, and

Green Swamp Dams Nos. 1, 2, 3 and 4 were complete and were given final inspection.

The construction of all dams has been done in accordance with the approved plans and in a thoroughly workmanlike and satisfactory manner.

John N. Brooks

John N. Brooks
Hydraulic Engineer.

3/31/28

Trenton, N. J.

March 30, 1928.

(New Jersey - Dept. of Environmental Protection)

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NATIONAL DAM SAFETY PROGRAM. WOLF DEN DAM (NJ00215), PASSAIC RI--ETC(U)
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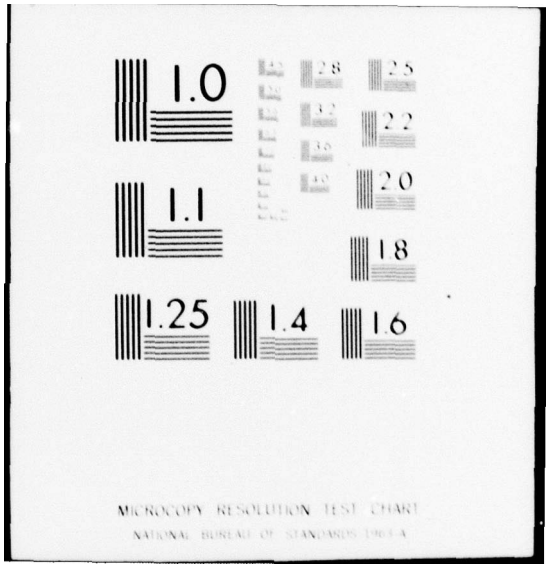
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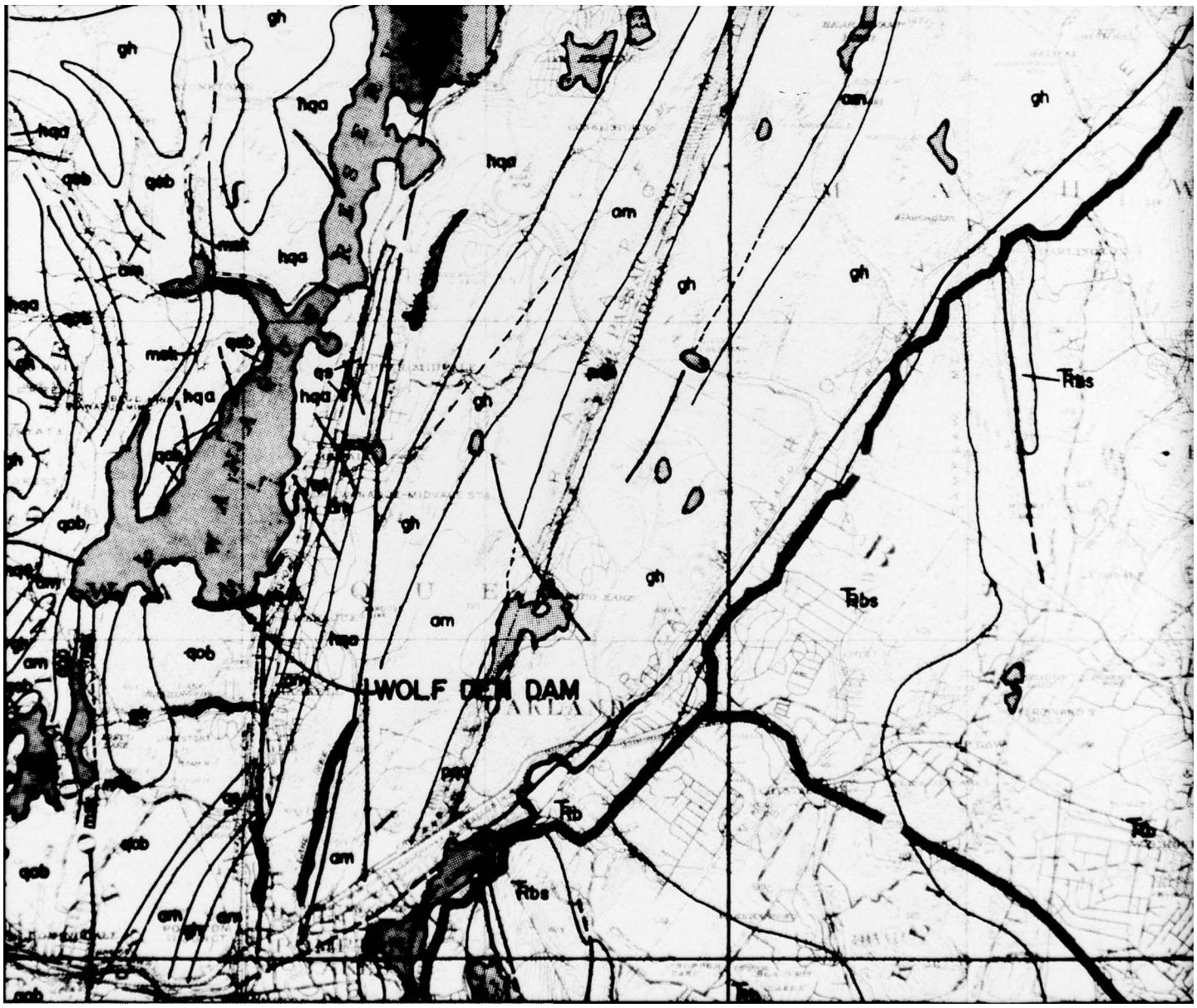
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

APPENDIX F

REGIONAL GEOLOGIC MAPS


WOLF DEN DAM
gh
hqa
qob
am
Tbs
Tb

LEGEND

TRIASSIC

Trb	BRUNSWICK FORMATION
Trbs	BASALT FLOWS

PRECAMBRIAN

gh	MOSTLY HORNBLENDE GRANITE AND GRANITE GNEISS
am	AMPHIBOLITE
pqo	PYROXENE GNEISS; MAINLY QUARTZ-OLIGOCLASE - CLINOPYROXENE GNEISS
hqa	PYROXENE GNEISS; MAINLY QUARTZ-ANDESINE GNEISS WITH BOTH ORTHO-AND CLINOPYROXENE
qo	QUARTZ-OLIGOCLASE-GNEISS
qob	QUARTZ-OLIGOCLASE-BIOTITE GNEISS
qs	SILLIMANITE GNEISS
msk	MARBLE AND SKARN

——— CONTACT LINE

——— FAULT LINE

NOTES:

1. THE PRECAMBRIAN MAP UNITS REPRESENT GENERALIZED GROUPINGS OF ROCK TYPES BASED MAINLY ON MINERAL COMPOSITION. THERE IS MUCH LOCAL VARIATION IN THE MINERAL COMPOSITION.
2. THE CONTACT LINES AND FAULT LINE SHOWN ON THE DRAWING ARE DASHED WHERE INFERRED.

SOURCE:

NEW JERSEY GEOLOGICAL SURVEY TOPOGRAPHIC SERIES AND GEOLOGIC OVERLAY SHEETS 23.

1 0 1 2

SCALE IN MILES

APPENDIX F
REGIONAL GEOLOGIC MAP SHOWING DAM LOCATION

APPENDIX G

REFERENCES

APPENDIX G

REFERENCES

1. Recommended Guidelines for Safety Inspection of Dams, Appendix D, (Washington, D.C., Department of the Army, Office of the Chief of Engineers).

2. North Jersey District Water Supply Commission - Report 1925, (Newark, N.J., Office of the Commission), 1925.

3. Public Works, Vol. 54, No. 5, May 1923.

4. Water Resources Data for New Jersey, Part 1, Surface Water Records, United States Department of the Interior, Geological Survey.

5. HEC-1 Flood Hydrograph Package, Hydrologic Engineering Center, Corps of Engineers, January, 1973.

6. Daily Reservoir Water Level and Discharge Record files from October 1950 to date by the NJDWSC.

7. Water Resources Data for New Jersey, Part 1, Surface Water Records, USGS. Department of the Interior.

8. "Passaic River Basin - New Jersey and New York Survey Report for Water Resources," New York District Corps of Engineers, June 1972.

APPENDIX H

CONDITIONS

APPENDIX H

CONDITIONS

This report is based on a visual inspection of the dam, a review of available engineering data and a hydrologic analysis performed during Phase I Investigation as set forth in the Recommended Guidelines for Safety Inspection of Dams, as modified by the contract between the U.S. Corps of Engineers and Gilbert Associates, Inc., Contract No. DACW61-78-C-0114.

The foregoing review, inspection, and analysis are by their nature limited in scope. It is possible that hazardous conditions exist and that conditions exist which with time might develop into safety hazards and that these conditions are not detectable by means of the aforesaid review, inspection, and analysis. Accordingly Gilbert Associates, Inc. cannot and does not warrant or represent that conditions which are hazardous do not exist, or that conditions do not exist which with time might develop into safety hazards.

As required by the Corps of Engineers the terms "good", "fair", "poor", "condition" have been used in this Report to characterize the information obtained from the aforesaid review, inspection, and analysis. The definitions of these terms as used are:

"good condition" - minor studies or remedial measures are required.

"fair condition" - sizeable studies or remedial measures are required due to deficiencies which could be hazardous depending on conditions. Immediate attention is required.

"poor condition" - major studies or remedial measures are required due to deficiencies which could be hazardous depending on conditions. Immediate studies or corrective action is required.